JANUARY 1972 60 CENTS

Popular Science

THE *What's New* MAGAZINE

GETTING HIGH ON HOT AIR

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ow Apollo 15 Changed Our Ideas bout the Moon
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ECRETS OF KEEPING OUR AUTOMATIC ISHWASHER ROUBLE-FREE

TEAM BUSES ARE HERE
Already Rolling Out West

OISY LITTLE ENGINES
an We Quiet the Racket om Mowers and Motorbikes, nowmobiles and Chain Saws?

. plus 17 other exciting articles, a big hat's New Digest, 11 great every-month features

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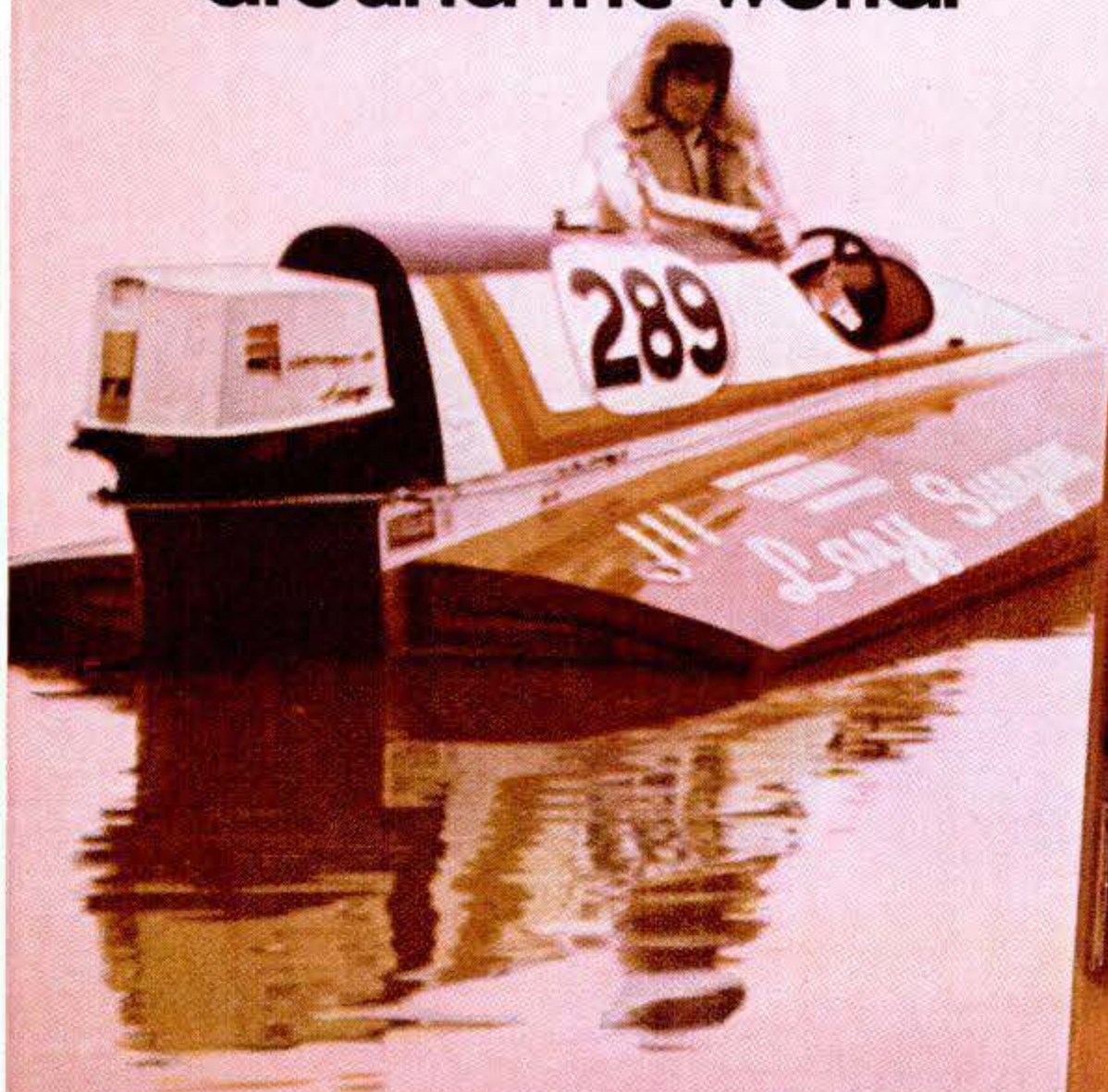
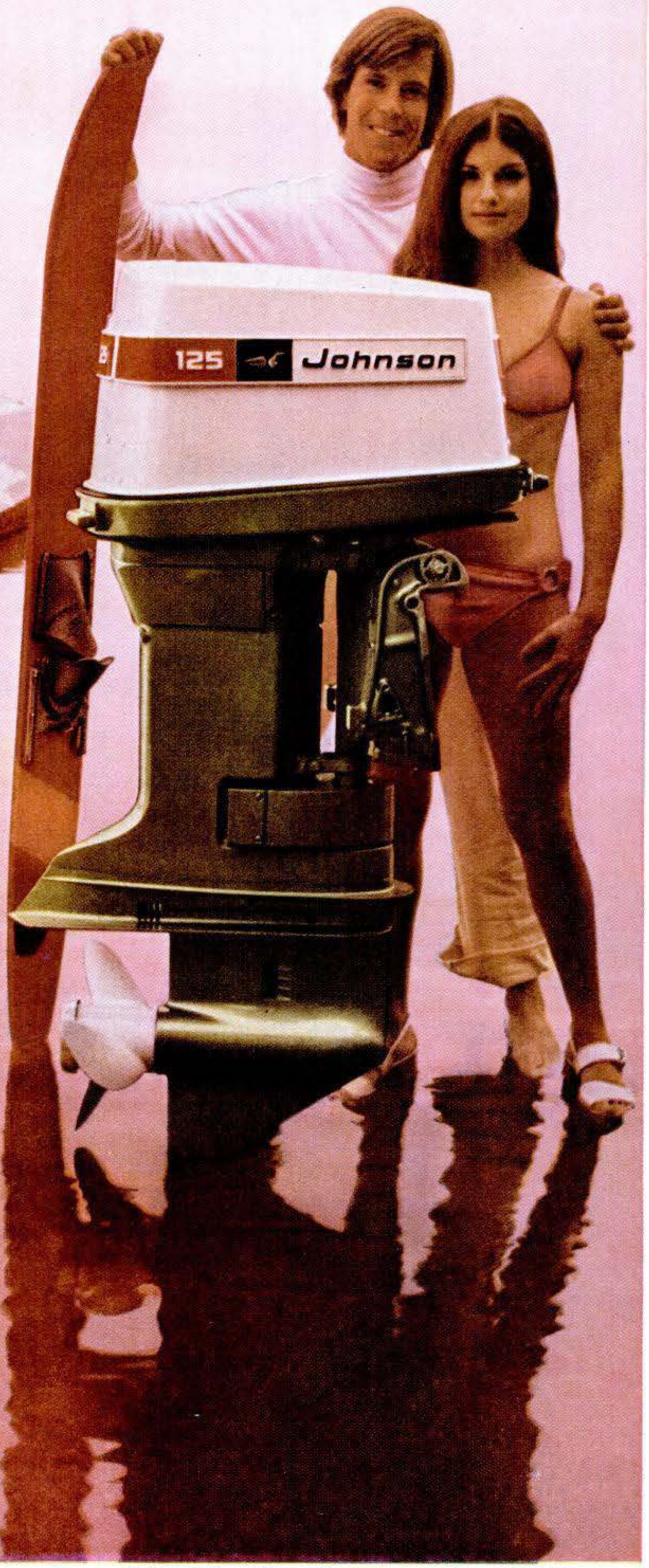
Exhaust tuning and CD ignition.

Two reasons Johnson wins races and friends around the world.





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This September the Subaru, coming from behind, outsold Saab, Peugeot, Porsche, Renault, and Audi.

Wall Street Journal, 10/6/71.

This winter, in the ice & snow & sleety rain, the people who bought the Subaru are going to be very glad they did.

The Subaru G

Do you know what just our front-wheel drive alone can do? On ice & snow it digs in and pulls you like a tow-truck; and the way it keeps its nose to the road in gusty winds, its tail in line on curves, holds a tight turn on a slick wet road is almost unbelievable. (Know how it climbed the Japanese Alps to win the Japan Alpine Rally? In the rain, in the pouring rain.) It's the kind of driving traction, steering traction, stability and control no rear-wheel drive can give.

If the car ahead goes into a sudden spin, we're ready with a steering system few cars can match: rack-and-pinion linked up to center-pivot steering, for the kind of maneuverability and quick response you need. "Superb steering," says Motor Trend, "precise and light."

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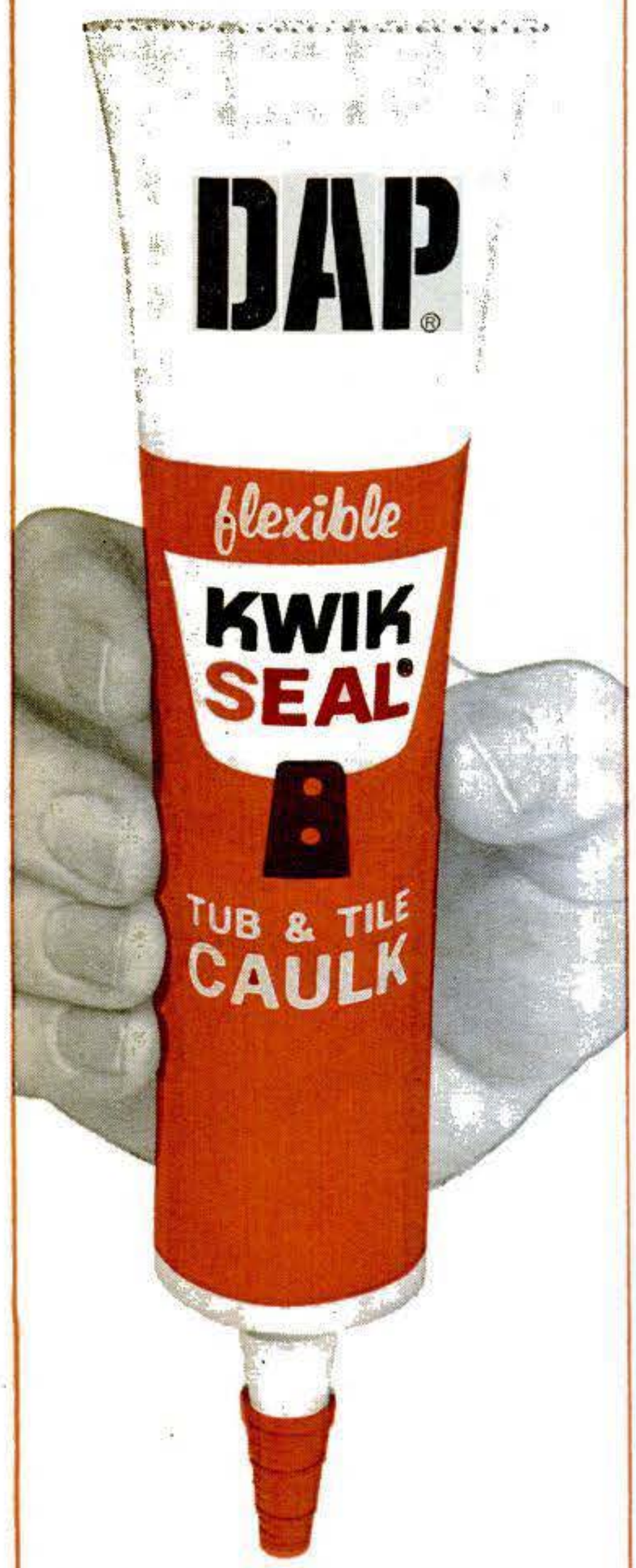

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THE What's New MAGAZINE™

JANUARY 1972 Founded in 1872/Vol. 200, No. 1

HIGHLIGHTS OF THIS ISSUE:

The Steam Power Story STARTS PAGE 56
Now—all external-combustion engine systems in one package . . . Steam buses are rolling in the West . . . Are steam autos still on the boards?

How Apollo 15 Changed Our Ideas About the Moon By Wernher von Braun PAGE 66
Scientific booty from this spectacularly successful mission tops all.

Wankel Engine in Your Next Car? PAGE 83
PS puts 10,000 miles on the new Mazda, then runs it through the standard tests on the track. Results will open your eyes.

Getting High on Hot Air PAGE 86
You can have a ball in a hot-air balloon, as PS editor Ray Hill did.

Keeping Your Automatic Dishwasher Trouble-Free PAGE 99
PS Extra: 6-page tear-out tells you how to check and fix your own machine.

COVER PHOTO BY OZZIE SWEET

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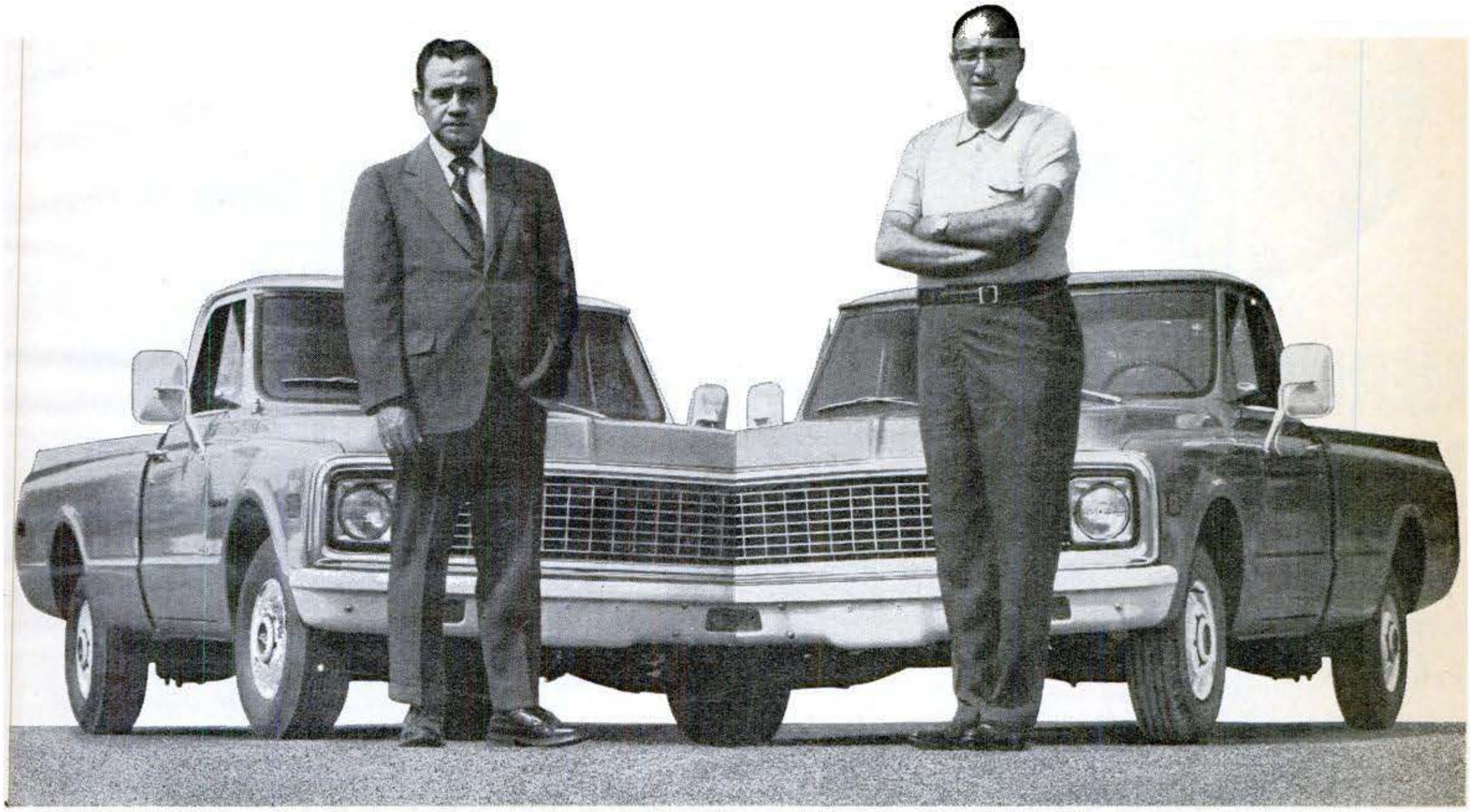
I can buy passenger car tires for less than truck tires and get the same mileage out of them.

I can buy truck tires for less than car tires and get more mileage out of them.



Do you know which man is right?

To a lot of people, "truck tire" sounds expensive, and because passenger tires will fit their pickups or vans, they reason they can save money with them.

Did you know you can buy a real truck tire—the Firestone Transport—with a 6-ply rating, for about $8 to $10 less than a comparable size original equipment passenger car tire? And get longer mileage in truck service with the truck tire?

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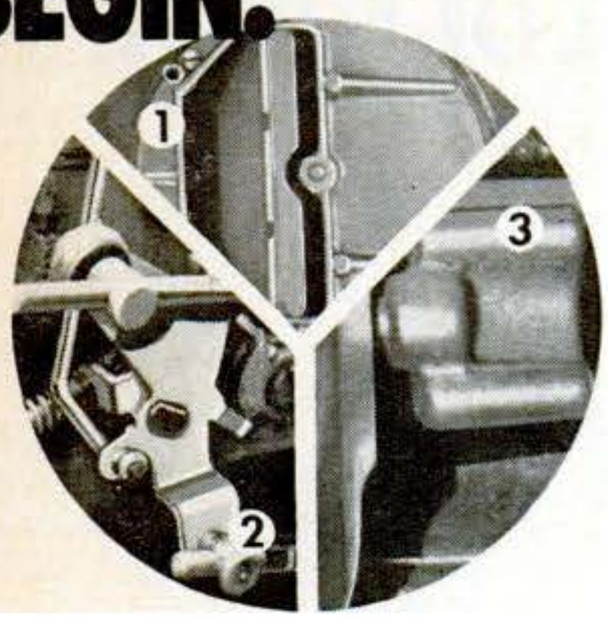

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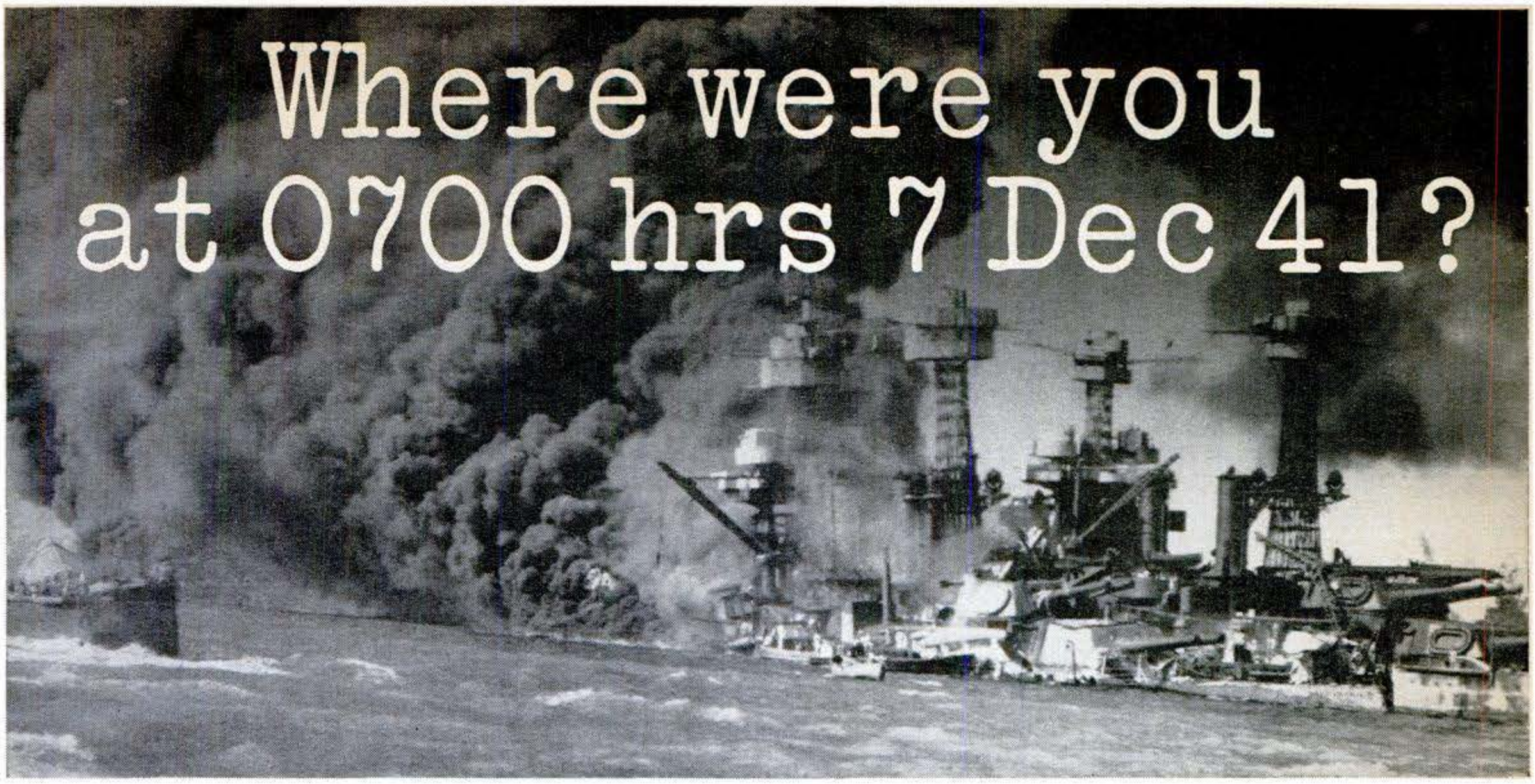

Here are the books that will help you remember and understand World War II—the five most momentous years of your life.

PEARL HARBOR. D-Day. Anzio. Guadalcanal. Midway. Whether you were in uniform or too young to serve, the books on this page illuminate the war years as no other books can.

Would you like to know what it was like to fly a nighttime raid over Berlin? Read *Flying Fortress.* Want to discover why Eisenhower refused to let Patton push on to Berlin? Read *History of the Second World War.* Are you curious to see Admiral Yamamoto's plan to bring America to its knees? Read *Two-Ocean War.*

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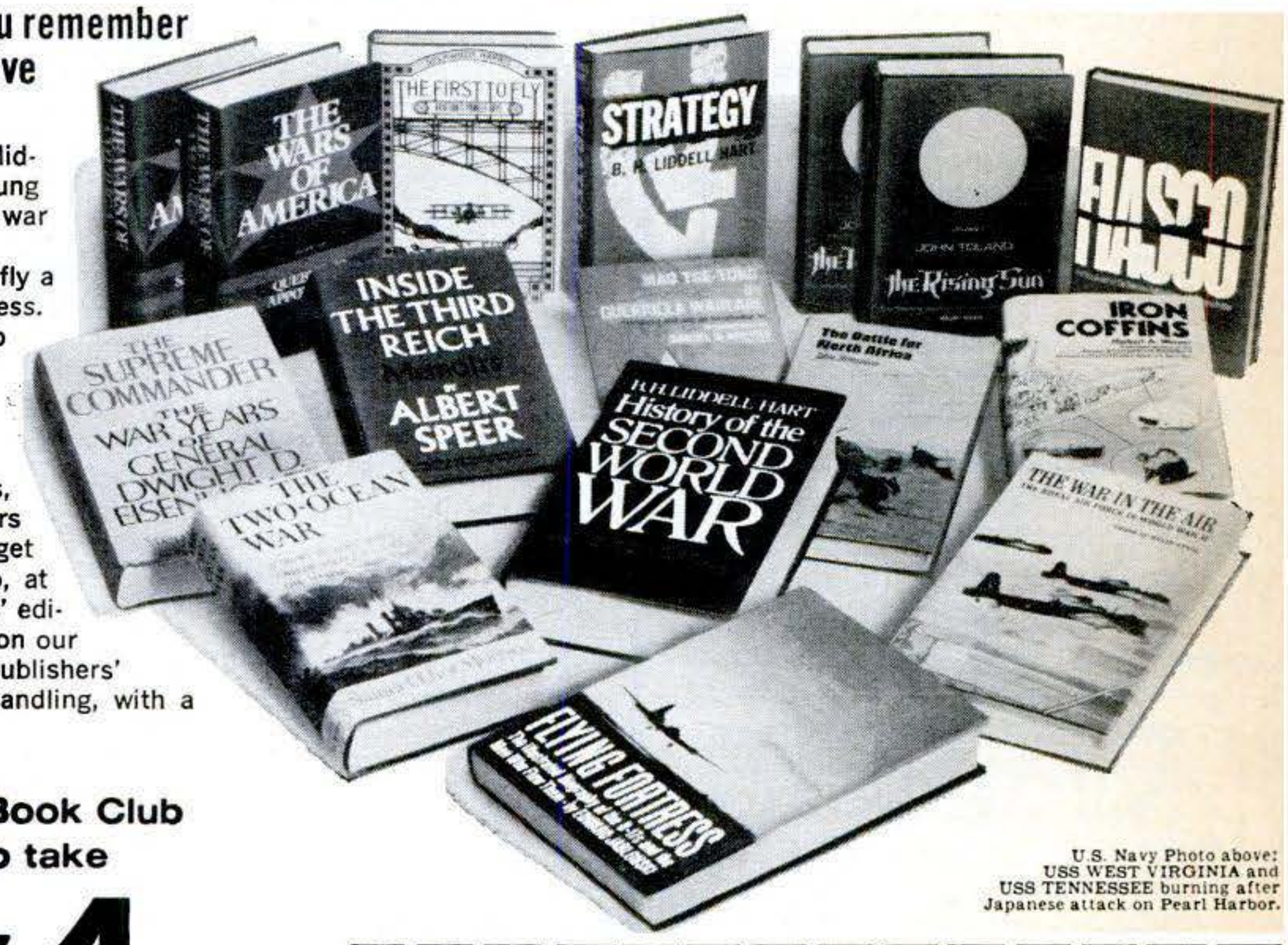

U.S. Navy Photo above: USS WEST VIRGINIA and USS TENNESSEE burning after Japanese attack on Pearl Harbor.

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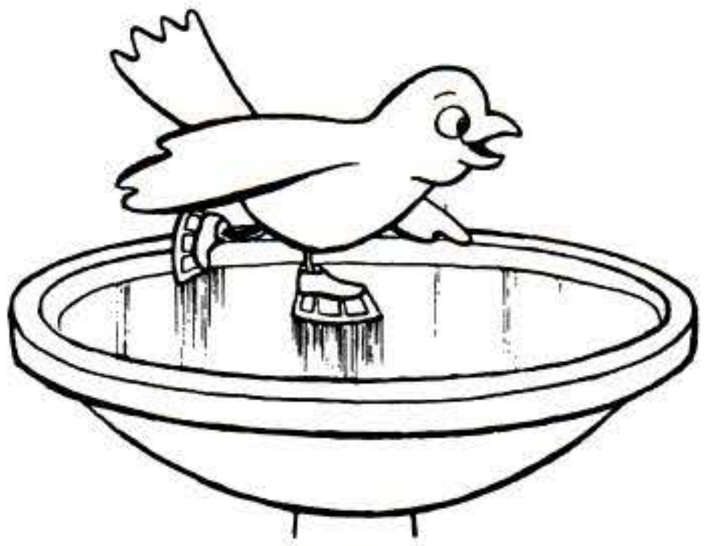
nice inexpensive card table [see photo on page 6]. The larger top provides some much-needed leg room.

KEITH ELLIOTT, Evansville, Ind.

Hint for the birds

All summer, birds have enjoyed our birdbath, but now that the water has turned to ice they are disappointed. I



have tried to think of some way of providing water—even installing a bulb under the bath and keeping it going day and night. But this runs into money when spread over six months. Perhaps your readers might have some practical alternatives.

Mrs. W. R. BRISTOW, Fairfield, Iowa

Heating tape has been used successfully to keep birdbaths from freezing.

Picture clocks for jr. businessmen

The picture clock would be a worthwhile project for our local Junior Achievement company of high-school students. We would assemble and sell the finished project. Could we purchase kits at less than $19.95 each?

G. J. FRANKOVICH, Sandy, Utah

Because Picture Clocks were offered as a reader service, our profit margin is low and we can't allow much of a wholesale reduction. However, to support such a worthwhile enterprise, we will supply clocks in lots of 10 or more for $18 each. When painted they can be sold for $30 to $35 each. Send orders to Treasurer, Popular Science, 355 Lexington Ave., New York, N.Y. 10017.

Snow-removal problems

C. A. Fenner's "Snow Rake for the Roof" [Nov.] was very interesting, but I wish he or someone else would advise how to prevent snow from melting on the roof. In this part of the country his method would be almost a daily chore for about six months of the year. The snow would also have to be shoveled from the sidewalk where it falls after being scraped from the roof.

GEORGE P. KLING, Wauwatosa, Wis.

More light on star gazing

In "Star Gazing the Easy Way" [Oct.], Marshall Lincoln says that by using a camera to photograph star trails, you are proving that the Earth rotates on its axis. He's wrong. Rotation proofs are coriolis effects, which means that depending on your latitude your linear speed is different. At the equator your linear speed is about 1,060 miles per minute, at 41 degrees north latitude (New York), your linear speed is about 600 mph, and at the north and south poles, your linear speed is 0 mph. It's because of this differential in linear speed depending on your latitude that the proofs of rotation work. You cannot assume that the Earth rotates from a star-trail photo, because is it not possible that the stars are moving?

Lincoln also calls the Pleiades a constellation. The Pleiades is not even an asterism, but a very minor set of stars—although beautiful. The Pleiades actually is a group of 300-400 stars known to astronomers as an open star cluster.

MARTIN STEINBAUM, New Rochelle, N.Y.

You're right. We could more accurately have called the star trails a demonstration, rather than a proof, of the Earth's rotation. It's also true that the Pleiades is a cluster and not a constellation. In common usage it is sometimes referred to as a constellation, meaning a recognizable group of stars.

Cause of reduced mileage?

I built the "Dwell Extender for Your Car" [Oct.] and found it dropped my gas mileage by over 10 percent. I used the given values of R2 and R3, and 680 ohms for R1. My engine ran smoothly and had good power, but lost mileage. Is there any alteration available to help this situation? I have a Jeep Wagoneer with 350-hp V8.

LEO TIMP, Wise, Va.

Try disconnecting the dwell extender and check your mileage without it. The drop in mileage may be due to some other factors. The extender itself should not cause a drop in your mileage.

Camper plans

While my family and I were on our vacation trip last summer, we saw one of the redwood campers that I remember

reading about in PS several years ago. It really looked great. One of the best-looking rigs on the road! Are plans for building the camper still available?

HOWARD PARSONS, Los Angeles, Calif.

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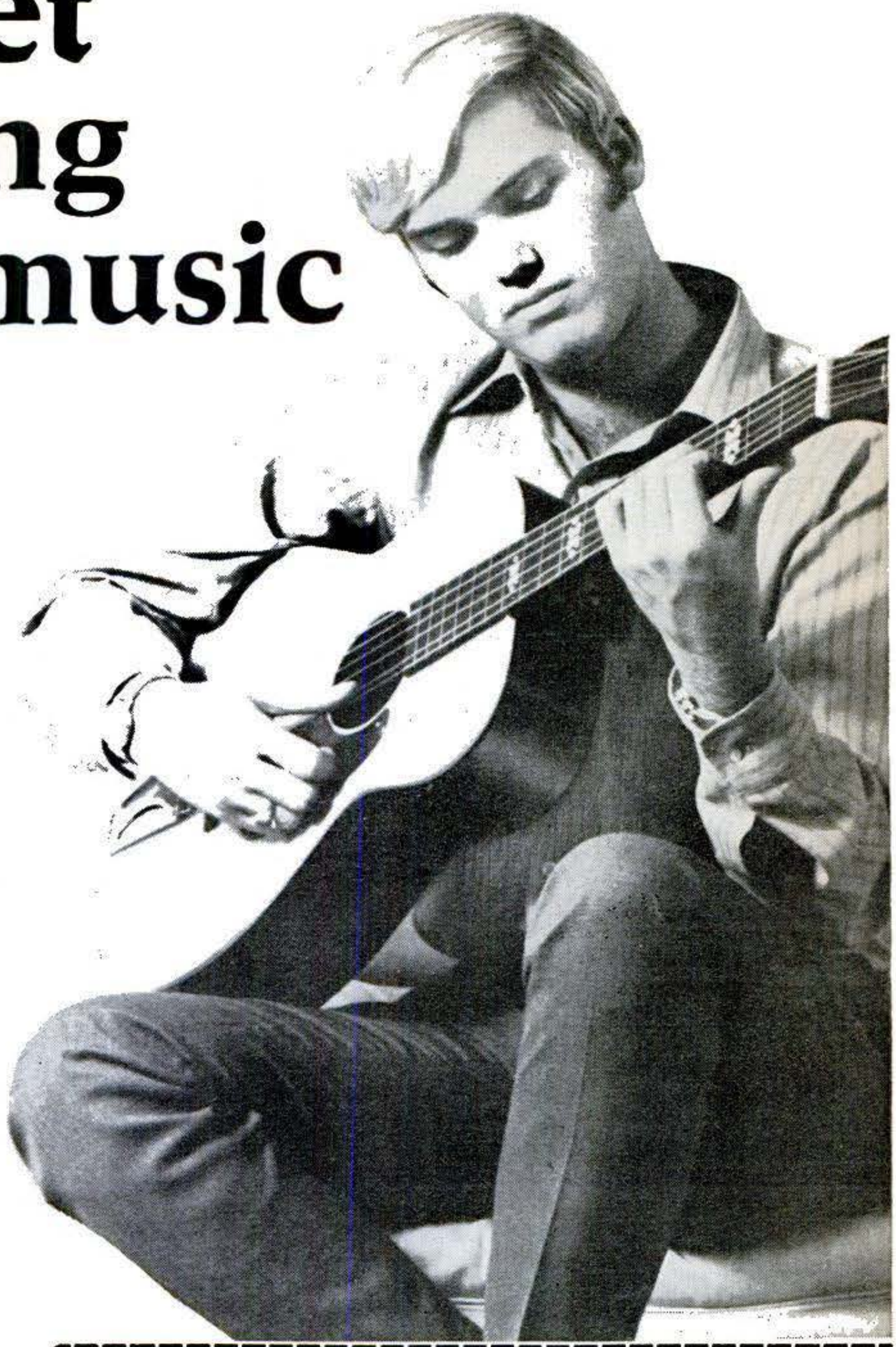
The secret of teaching yourself music



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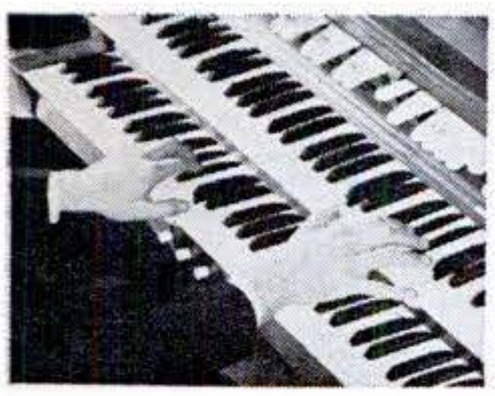

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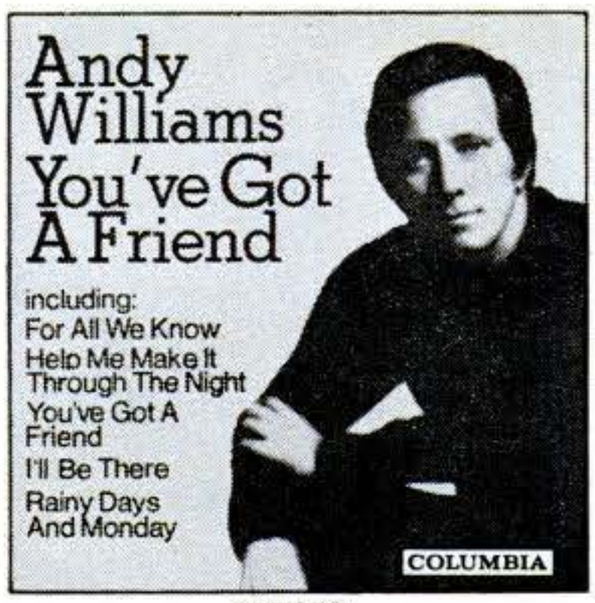

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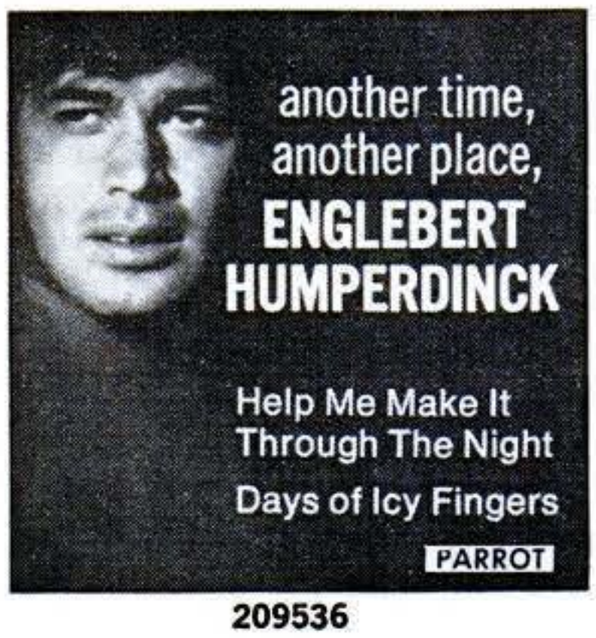

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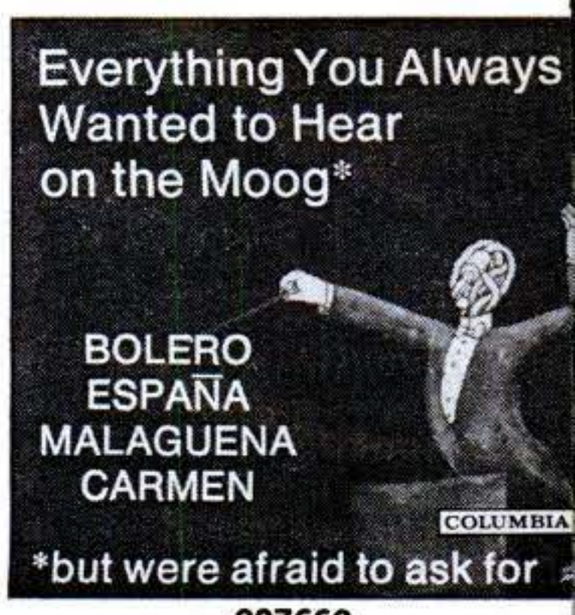

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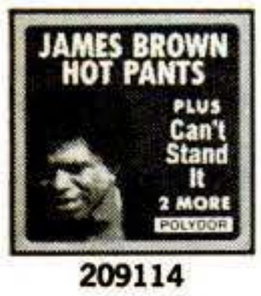

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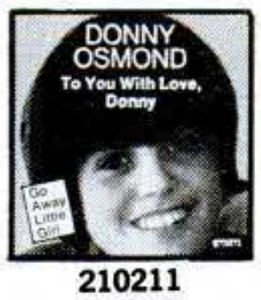

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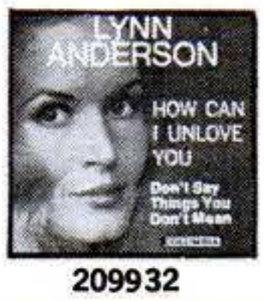

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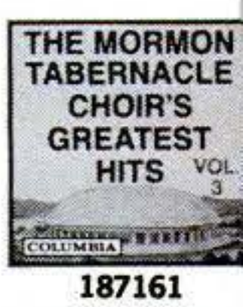

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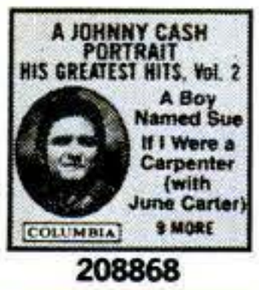

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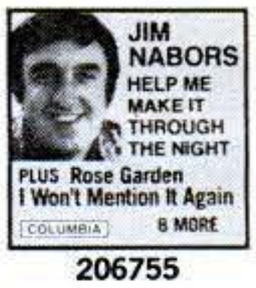

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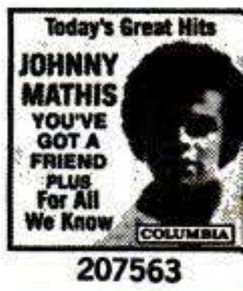

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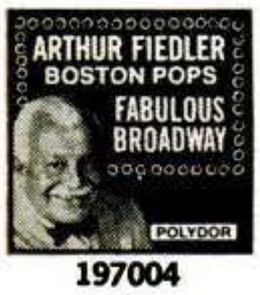

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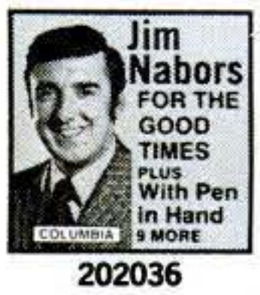

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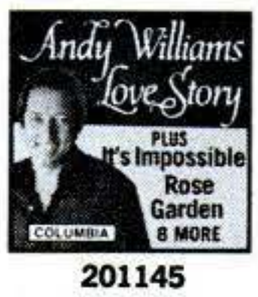

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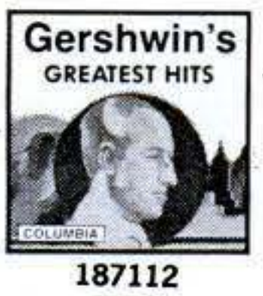

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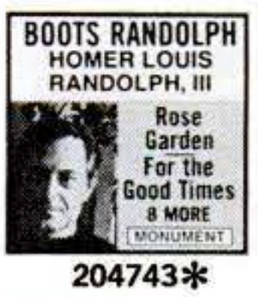

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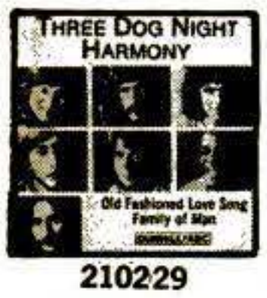

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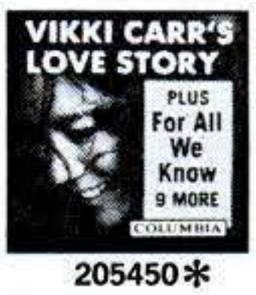

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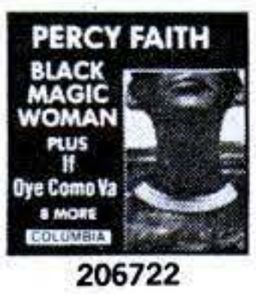

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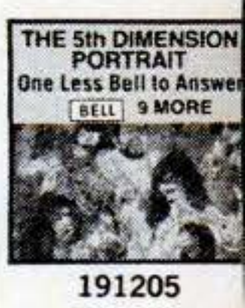

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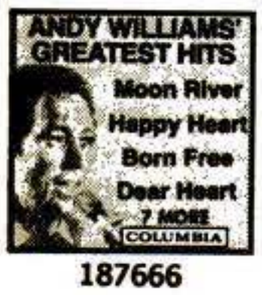

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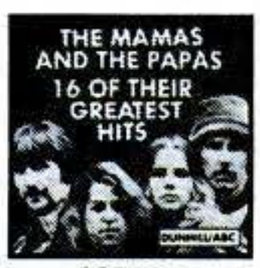

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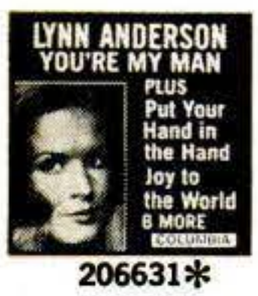

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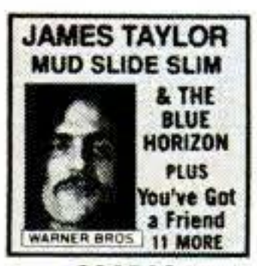

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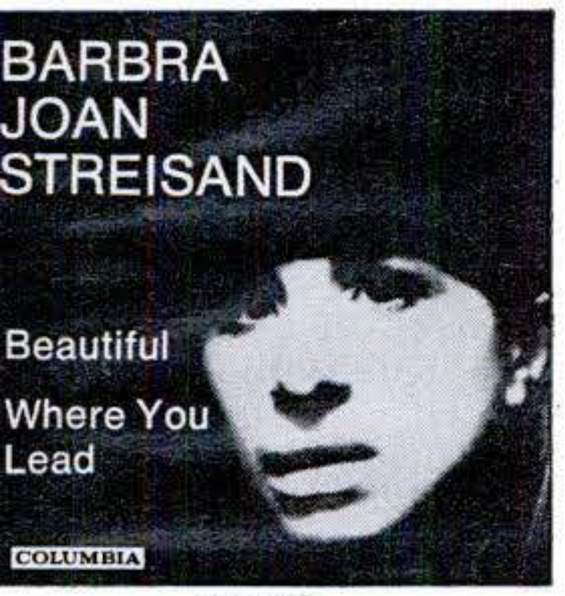

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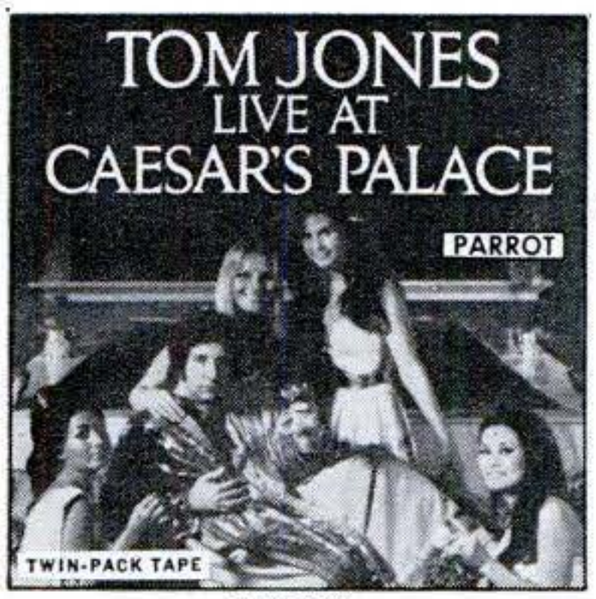

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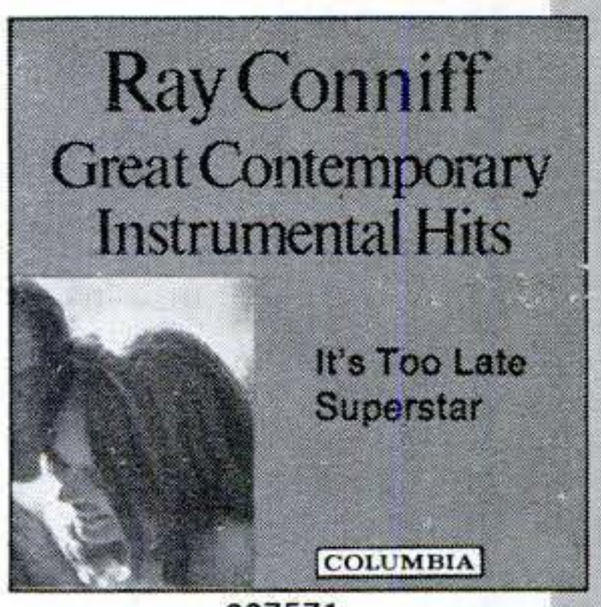

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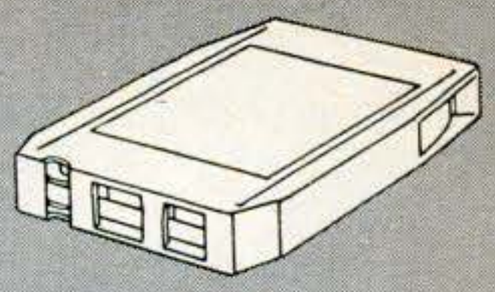

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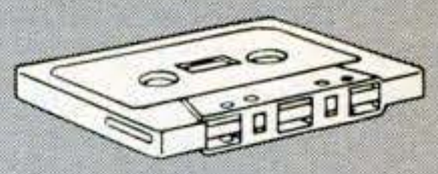
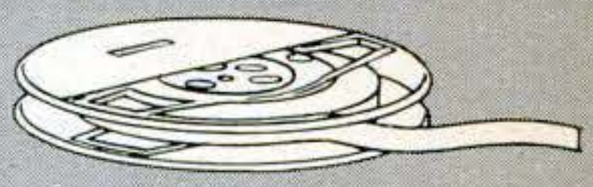


tape cassettes

OR



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☐ **Mrs.**
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Do you have a telephone? (check one) ☐ **YES** ☐ **NO**

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The View Down the Road

...news and comment on cars and driving

By **JAN P. NORBYE** / *PS Automotive Editor*

New Wankel developments

One of the last stops on my European tour was a visit with Dr. Felix Wankel and a look at his test establishment. The inventor is as busy as ever, and is engaged on a program of finding other (i.e., non-engine) applications for the mechanical movements and pumping actions he has invented. He showed me two devices that seem ready for production.

The first is a pump for an automotive air-conditioning system. The rotor has only two lobes, in contrast with the three-lobe rotor in the Wankel engine. The rotor profile is elliptical, with pointed ends. The chamber is almost circular, with a depression in one side—like the silhouette of an apple. This pump is smaller, lighter, and cheaper to make than the multipiston swash-plate pumps now used in most auto A/C systems. And Dr. Wankel claims that it has a substantially lower horsepower requirement. That's especially important with smaller engines, for the A/C system can rob up to eight hp from your useful power.

The other device was smaller still—a tiny air pump intended for an air-injection-reactor system (part of the exhaust-emission-control system on many U.S. cars). A seven-lobe plastic rotor runs in a six-lobe chamber, with axial feed and radial delivery. It's about one-fifth the size of the present GM AIR pump, and the weight saving is even more spectacular. Dr. Wankel says it will also work better. Why? The GM AIR pumps are belt-driven, and slow down when the engine slows down. The Wankel AIR pump is driven by a small electric motor that maintains high speed during deceleration and at idle (when the need for additional air is greatest).

Wankel builds his own diesel

Two men in the machine shop were busy making parts for a new type of Wankel engine with an almost square rotor. Dr. Wankel showed me the blueprints, and explained that it was his diesel engine.

The rotor runs in a three-lobe chamber, and precompressed air is delivered via a peripheral intake port from a Wankel-type compressor running on the same shaft as the rotor, at the same speed. Final compression is calculated to raise the gas temperature sufficiently to cause ignition when fuel injection is completed, but that's a little late to assure complete combustion. To be safe, a glow plug will be provided to start ignition earlier.

The power phase is followed by secondary compression (in the final lobe of the chamber), which in turn produces internal afterburning and manages to put the energy released to useful work. Testing should begin by the time you read this, and I hope to report results soon.

Drive-yourself taxicabs?

There are many reasons why cab fares are high in America. The cabs are expensive, they burn a lot of gas because their engines are big, and the drivers are expensive.

In the town of Montpellier in the south of France, they have eliminated the cab driver. Cabs are lined up in cab ranks along the sidewalk on certain blocks all over the city. How do you take one? You sign up as a self-drive passenger with the Procotip company that operates a fleet of Simca 1000s. They give you keys that fit all of them. Each car has an electric taxi meter that runs on special tokens. The Simca is a low-priced car and is very easy on gas.

How does the cost compare? For one normal cab ride, you can give yourself four trips of similar distance and duration. Cabs are available day and night. The plan has been in operation for a couple of months, and so far all the riders have returned the cabs. Could it work here? We ought to test it. It could be the solution for New York City.

Fiat consolidates Italian auto industry

When I arrived in Torino, I got the news that Fiat had taken over Abarth. Abarth has been a small, specialist manufacturer of sports and racing cars, usually with Fiat engines and chassis components, for 22 years. What will happen to the Abarth name? It will be hyphenated to special sports and rally versions of Fiat and Autobianchi cars, developed in the Abarth shops. Autobianchi is a wholly owned subsidiary of Fiat. Fiat also controls Lancia and Ferrari, and the O.M. truck company. Indirectly (through Citroën) Fiat also controls Maserati.

At times it seems as if Fiat has taken over the entire auto industry in Italy. Yet there's always Alfa Romeo (part of government-controlled IRI). And there's Innocenti in Milano, building Austins under license from British Leyland. And there's Lamborghini, now controlled by a Swiss group of industrialists. And don't forget De Tomaso (owned by Ford Motor Co.), maker of the Pantera.

You've got seat belts—why not use 'em?

We don't know if the air bag and its sensors can ever be perfected. But most cars on the road are now equipped with belts. There's only one problem: They don't work if they're not used. But if you put them on, they work very well. How well? A study by Volvo shows that in more than 28,000 highway accidents, nobody wearing a combination shoulder/lap safety belt lost his life.

Only about three percent of U.S. drivers use both lap and shoulder belts. Why? One reason is that the auto industry has not done a very good job of making belts easy to use. Many are a real mess. Tangles of belts and buckles on seats and floors do not invite use. In my opinion, improved seat-belt systems will do more to promote their use than any advertising campaign. And the American Safety Belt Council would have a better case in its opposition to air bags.

Check your tires this winter

A drop in ambient temperature will cause a loss of tire pressure. For every 10 degrees' drop, tire pressure will go down about one psi. Check inflation regularly. That's the best advice I can give you. Oh, yes—one other thing. Never bleed air from your tires to get better traction on ice. We've said it before, and I'll say it again: Letting air out only reduces traction and stability, and will ultimately cause tire failure (cord separation in the sidewalls).

Electric urban cars

The engineering staff of Citroën is working on an electric commuter car for future cities. It is planned as a self-contained vehicle with fuel cells as the power source. The problem with fuel cells may surprise you: It's pollution. The fuel cell works by chemical reaction, and as with all other chemical reactions, it may leave waste products. Citroën is not alone, however, in its efforts to arrive at a clean fuel cell—the auto maker is working jointly with Total petroleum company, and making progress. It's too early to talk about a fuel cell that eats dirty air and exhausts clean air, but that's the long-term objective. When can you buy an electric Citroën? In the distant future, at best. PS

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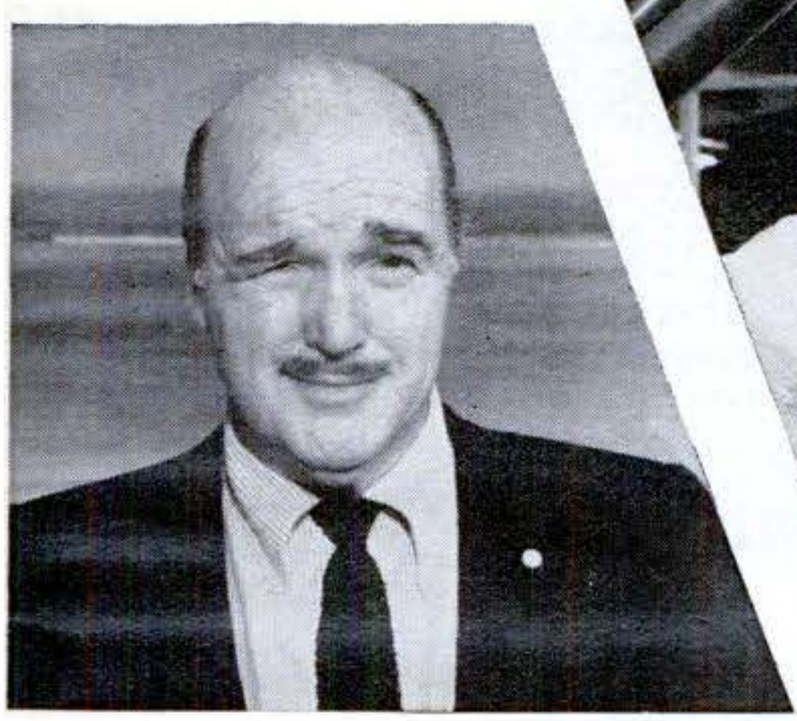

TOM McCAHILL

"I'm beginning to have some hope about finding good mechanics again."

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Tom McCahill

America's foremost automotive editor/critic

RICHARD PETTY

"It's a lot of training for a very few bucks."

"I especially like the way NRI has programmed essential training equipment they give you into step-by-step instruction. There's nothing like learning with your hands, and having exactly what you need to do the job. The fact that the Master Automotive Technician course includes (among other things) an ignition-analyzer scope, dwell tachometer, timing light and exhaust analyzer is an indication that it's a lot of training for a very few bucks. Even the shorter Tune-Up course includes basic tools and equipment at no extra cost. I'm sure Petty Enterprises would give top consideration to a man with an NRI diploma."

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"I've seen a lot of training programs and this one is up there with the best."

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William H. G. France

President of NASCAR and International Speedway Corp.

*William H. Crouse, author of NRI mechanics training, is an internationally known automotive training expert. He knows what you need to know, whether you choose NRI's Master Automotive Technician training or the shorter Automotive Tune-Up and Electrical Systems course. Both courses include, at no extra cost, training and diagnostic equipment essential for both education and car care. Mail the coupon for full details. NRI AUTOMOTIVE TRAINING, Washington, D.C. 20016. No salesman will call.

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To wash or not to wash—and moreover, with what? Here's how you can unscramble all those conflicting claims

THE DETERGENT MESS... What to Tell Your Wife

By SIMON DRESNER

The froth over detergents has bubbled over the lid of the washing machine and now threatens to engulf the man of the house. The laundry room, once the exclusive domain of the housewife, has become a battleground for ecologists, detergent manufacturers, and government agencies. The struggling housewife must tackle the dirty laundry with one hand as she juggles pollution, environment, detergents, phosphates, enzymes, caustics, and health with the other.

If you're not to lose your status as a science know-it-all, you'd better have some answers ready for your lady. A summary of good advice appears in the table below. For the real dirt behind the detergent controversy, read on.

Soap—grandma's standby

Soap has been in use thousands of years, ever since Roman women discovered that lye plus animal fats could take grease out of a toga. The secret of soap's success is that it is a wetting or surface-active agent—surfactant. A surfactant enables water to penetrate an oily surface and reach the dirt buried in the fibers of the fabric.

Soap's main ingredient, sodium stearate, also breaks down oil and grease into tiny particles and surrounds them with its own molecules, so they can't re-attach themselves to the fabric. Dirt particles flushed out are similarly isolated. Emulsified dirt and grease are then flushed away with the water, the clothes are rinsed, and the wash is done.

Though soap may clean well enough to remove the ring around a shirt collar, it is almost sure to leave a ring around the bathtub in hard-water areas. This scum is created as salts of calcium and magnesium in tap water combine with the emulsified soap particles. The presence of these and other minerals is what makes water "hard."

In pre-detergent days, when soap flakes and powders reigned supreme, housewives softened their wash water with washing soda (sodium carbonate), which combines with the calcium and magnesium ions to make a fine, powdery, insoluble material. This precipitate must be thoroughly rinsed out, or pressed out by a wringer, or it becomes trapped in the fabric, making it harsh and stiff.

In the late 1940s housewives gratefully threw away their soap boxes and turned to detergents for two compelling reasons: The detergents' more effective wetting agent cleaned clothes more easily, and another ingredient, a phosphate, softened even the hardest water, leaving no curd, precipitate, or residue of any kind.

The original detergent wetting agent, called ABS (for alkyl benzene sulfonate), produced billows of suds that pleased women who equated a nice lather with the rich soapy solutions they had used before. But the detergent suds flushed down the drain refused to give up the ghost, and reappeared as billows of foam at sewage plants, on streams, and even as "heads" on glasses of tap water.

Grapes vs. beads

ABS had a complex molecular structure resembling a bunch of grapes, which broke apart slowly after use. In 1956 the first test-tube sample of an ABS substitute was developed. It was called LAS (for linear alkylate sulfonate).

This new surfactant had a straight-line molecular structure, resembling a string of beads, that broke down quickly through biological action. By 1965, all detergents had converted to LAS. It is biodegradable—it is attacked by bacteria in sewage, surface waters, and soil, which break it down chemically for use as food. When digested, the wetting agent loses its wetting and sudsing power, and ultimately decomposes into harmless carbon dioxide and water.

Today, all detergents are a combination of surfactants and other chemicals that make them remarkably effective as cleaning agents. Here are the basic components of most modern detergents, as they existed before the big phosphate controversy:

1) A wetting agent (surfactant)

Continued

How to Choose and Use a Detergent

1) If you have young children, avoid the "nonpolluting" or "phosphate-free" detergents. They are a household hazard; like lye, they all are caustic to some degree and dangerous if inhaled, swallowed, or in contact with the eyes or skin.

2) If you wish to minimize pollution, experiment to find the least amount of detergent that cleans to your satisfaction. In many cases a fraction of the amount recommended on the box will do an excellent cleaning job. And your contribution to pollution will be cut proportionately.

3) If your sewage or septic field drains into a small lake, use low-phosphate or phosphate-free "nonpolluting" detergents. Use the least-caustic brand that does the job (see FDA table). Read the warning label, handle the stuff carefully. Use an extra rinse in the washing machine.

4) If your main concern is clean clothing, forget "whiteners" and "brighteners." These fluorescent substances merely make the fabric glow, with no indication of cleanliness.

5) If you have hard water, use phosphate detergents. They are the safest, and the most effective cleaning product. They leave no grey or stiffening residue in the laundry, and work perfectly well in washing machines.

6) Use enzyme presoaks only on certain stubborn stains: blood, grass, gravy, chocolate, diaper and certain fruit stains. Let clothing soak for hours. *Don't use enzyme-detergent combinations in washing machines, where they are ineffective.* Don't add chlorine bleach to enzyme soaks—the chlorine neutralizes the enzymes. Use enzymes only when specifically needed; they may have unknown effects on your health. Avoid inhaling or touching the product.

7) If you have soft water and lightly soiled laundry, phosphate-free and low-phosphate detergents will do a good job. Read the warning label.

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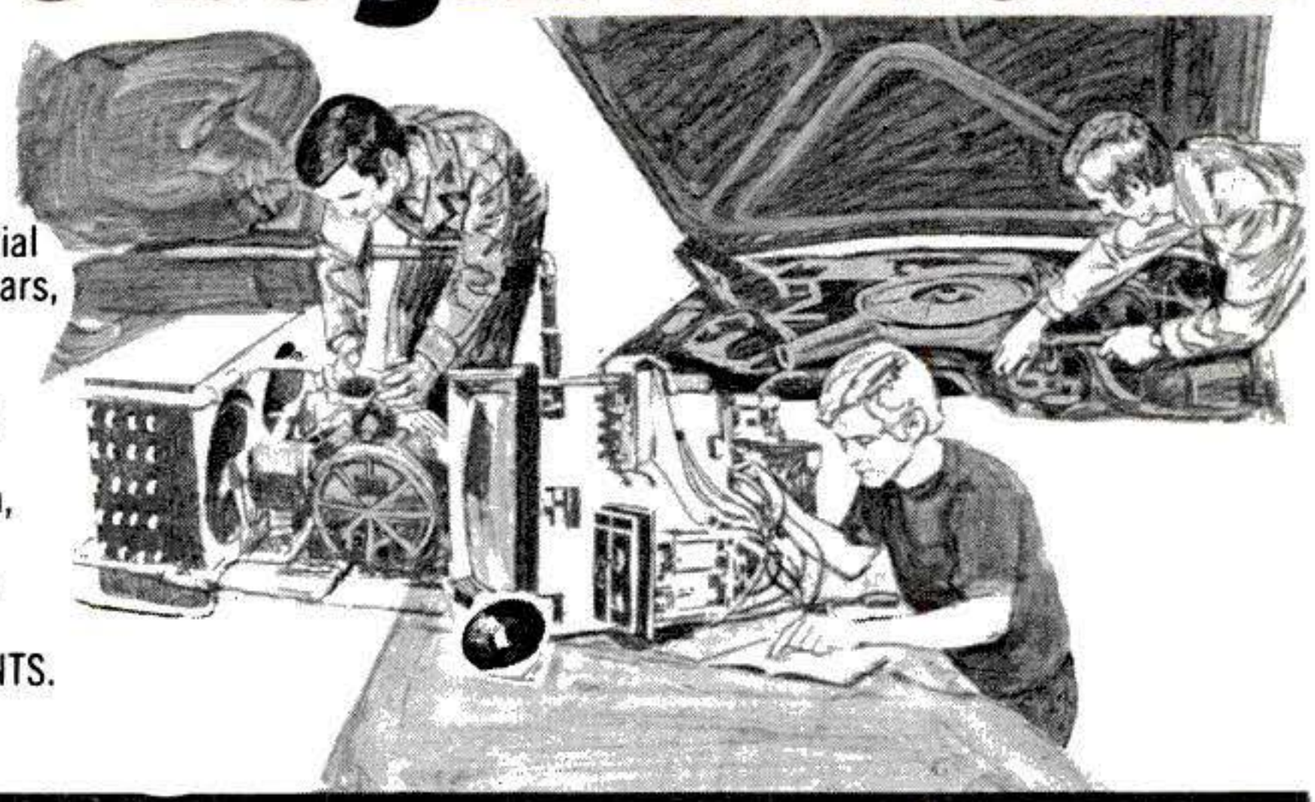

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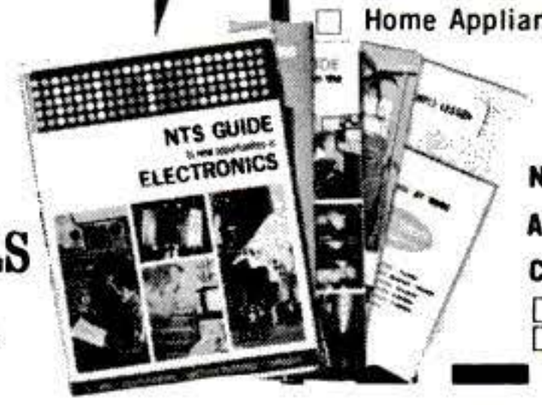

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that reduces surface tension and lets water soak into the fabric.

2) A "sequestering" agent that keeps emulsified dirt and grease particles from clumping together and prevents hard-water curd. This is one of several phosphate compounds (usually sodium tripolyphosphate), which are now being blamed for the "death" of lakes and streams. The phosphates (combinations of sodium, oxygen, and phosphorus) make up 20-40 percent of the powder in the detergent box.

3) An anti-redeposition agent (usually carboxymethyl cellulose) to prevent loosened dirt from re-attaching itself to the laundry.

4) Anti-caking agents (usually sodium silicate).

5) Fluorescent brighteners that glow a brilliant blue-white, making clothes seem brighter.

6) Oxygen bleaches, such as sodium perborate.

7) Fillers to add bulk to the packaged powder.

8) Perfume to add a pleasant odor.

All these substances are safe, biodegradable, and the combination greatly reduces washday drudgery.

Why the uproar?

The reason lies in the sheer bulk of detergent phosphates now being flushed down America's drains—about two billion pounds a year. The phosphates are not a poisonous pollutant, but the phosphorus (about one-fourth of the phosphates) they contain is an excellent plant food. The phosphorus finds its way into lakes and stagnant streams or bays where it nourishes algae.

The algae multiply rapidly into a thick green mass called algal bloom, which covers the water surface with slimy, foul-smelling mats and chokes off other plant and animal life. As the algae die and decay, they consume the dissolved oxygen necessary to fish and other aquatic animals. The lake then fills up with decaying matter and weeds, and eventually becomes a marsh, then a meadow. This natural process, by which lakes die and are filled up, is *eutrophication*.

Lake Erie and the other Great Lakes face premature eutrophication, along with innumerable other lakes, ponds, streams, and estuaries. Detergents are only partly to blame. Large amounts of phosphates (also nitrates, another plant food) drain off farmland as the residue of fertilizers. Human wastes are also rich in phosphorus. Poisonous effluents from industrial and chemical plants accelerate the death of aquatic life.

Some experts say it is possible that within 20 years, parts of the U.S. and Canada may be turned into a huge, sodden, "algal bowl" with nary a drop of clear water in sight. Many scientists feel that eutrophication is a global problem, with the very oceans in danger.

The NTA scare

Faced with this environmental threat, American and Canadian government officials moved to halt the phosphate flood from detergents. In a frantic search for a phosphate substitute, detergent makers latched on to NTA (nitrilotriacetic acid), a product that had been developed and used in Sweden with no conspicuous problems. At first NTA seemed to be an ideal phosphate substitute: It was not toxic, it was an effective sequestering agent, it was readily biodegradable, and it was cheap.

But in December 1970 the axe fell on NTA. The U.S. government released studies showing that NTA, which readily combines with poisonous heavy metals such as cadmium and mercury, facilitates the passage of these metals through the thin membrane that protects a fetus in the womb.

The experiments were carried out in mice, but if NTA-mercury-cadmium combinations could trigger birth defects in mice, it might have the same effect on human beings. Shortly thereafter, detergent companies withdrew NTA from their products.

RATINGS OF 37 DETERGENTS

The Food and Drug Administration has rated these detergents for potential health hazards:

Product	Phosphate	Rating	Product	Phosphate	Rating
Par	None	3	Drive	Yes	* *
M-W Lo Suds	None	1	Phos-Free	None	+
B-70	None	4	Bio-D	None	3
Crystal Clear	Yes	2	Sears	None	4
Concern	None	4	Fab	Yes	4
T-Rif	None	1	Breeze	Yes	2
Pure Water	None	3	Cheer	Yes	2
Giant OW	Yes	5	Logic	None	4
Phosphate Free	None	3	Cold Power	Low	+
Klean	Yes	5	Ecolo-G	None	4
Miracle White	None	3	Triumph	None	3
King Kullen	None	3	Acme	None	4
Arm & Hammer	None	2	Balance	None	5
Basic L	None	3	Un-Polluter	None	3
Controll	None	3	Trend	None	2
Burst	Yes	2A	Cold Water	Low	2
Cascade	Yes	2	PFD	None	4
All	Yes	2	Spring Clean	None	2
Tide XK	Yes	*			

FDA codes: 1. Caution, harmful if swallowed. 2. Caution, harmful if swallowed, eye irritant. 2A. Caution, eye irritant. 3. Warning, injurious to eyes, harmful if swallowed. 4. Warning, injurious to skin and eyes, harmful if swallowed. 5. Danger, may cause burns to skin and eyes, harmful if swallowed. * Eye and skin irritant. * * Toxic, eye and skin. + Eye and skin.

Which way to go?

The NTA scare placed government officials on the horns of a dilemma: preventing eutrophication of the nation's waters and still safeguarding the people against possibly dangerous phosphate substitutes.

Russel E. Train, chairman of the President's Council on Environmental Quality, reluctantly approved continued use of phosphates because to do otherwise would be "gambling with the health of the American people." Similarly, Dr. Jesse S. Steinfeld, the U.S. Surgeon General, has noted that NTA has caused cancer in animals, and has refused to endorse other phosphate substitutes. Says he: "I don't want to be Surgeon General while doing a carcinogenesis experiment on 200 million people."

Both the government and the detergent companies are doing extensive research on finding a phosphate substitute. Spencer Valmy, of Colgate-Palmolive, told POPULAR SCIENCE that C-P is "running 60 laundry machines every day all day long, testing every substance known to man as a cleaning agent. But a substitute for phosphates must be an effective cleaning agent, safe for human use, safe for the environment, and low in cost."

He doubted that such a substance would be found in time to meet local restrictions against phosphates now in states and municipalities.

A Lever Brothers spokesman told POPULAR SCIENCE that phosphorus in their detergents has been reduced to 8.7 percent by adding inert fillers—by putting less phosphates in each box, and making up the difference in bulk by adding an inactive material. This also reduces cleaning power, of course, so more powder must be used to gain the same cleanliness.

Study the label

In November 1970, soap and detergent manufacturers agreed to label packages according to the percentage of phosphorus in the formula, and also

[Continued on page 126]

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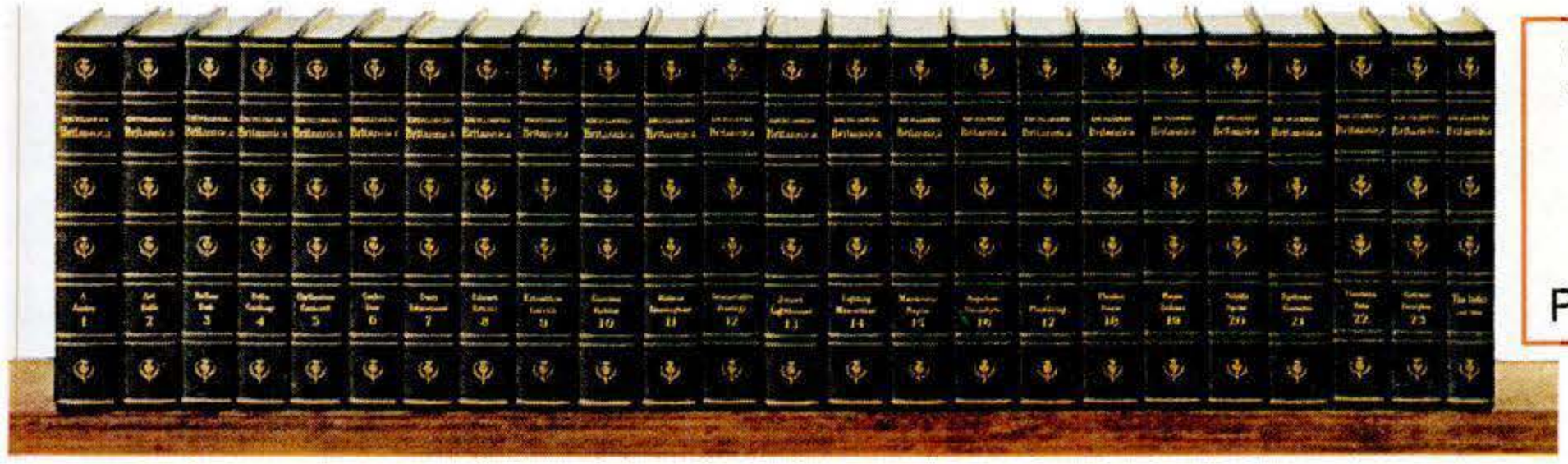

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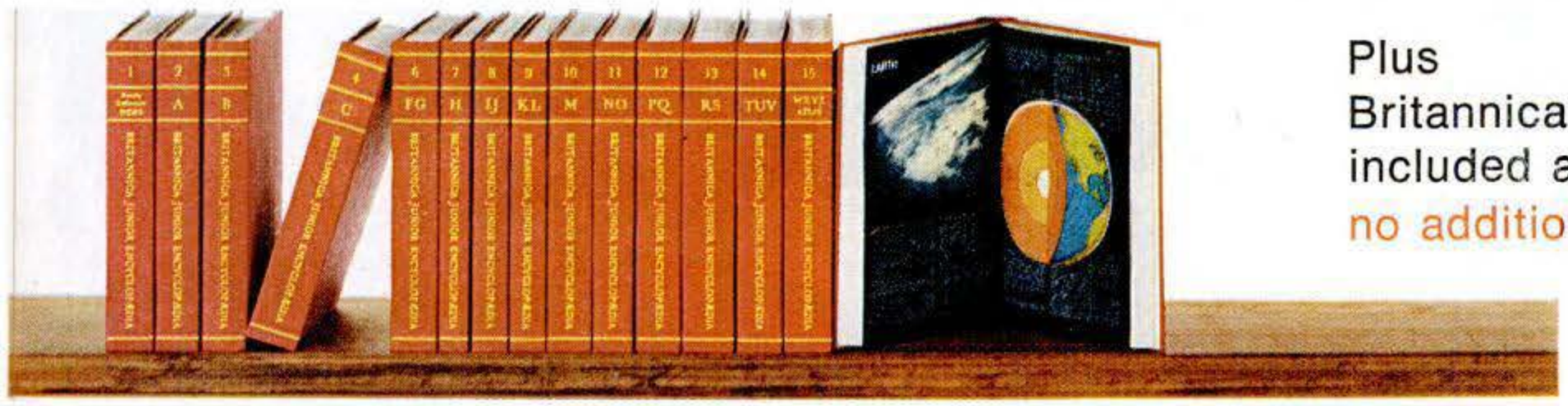

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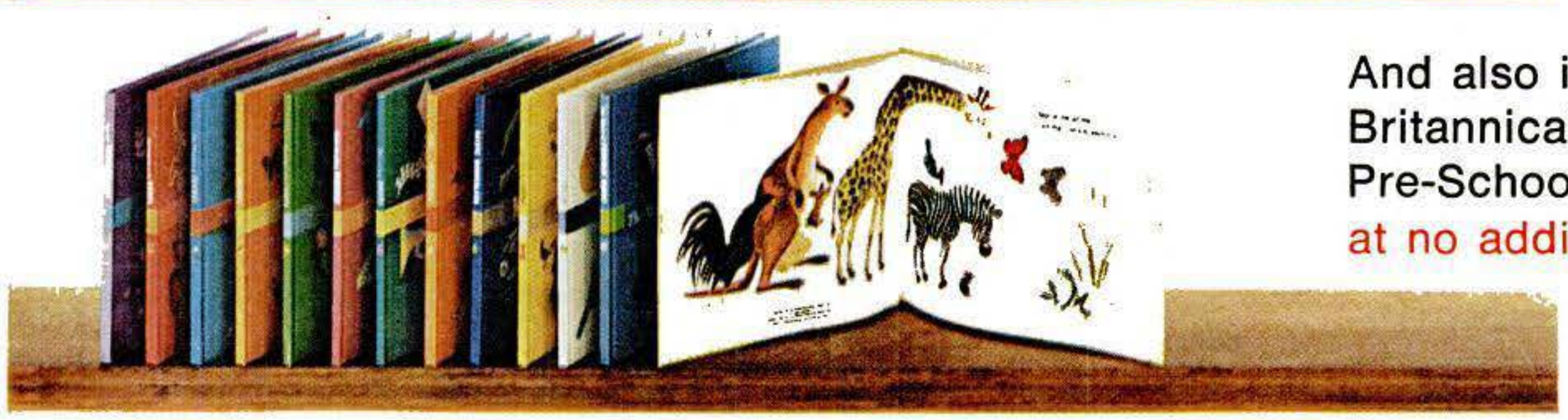

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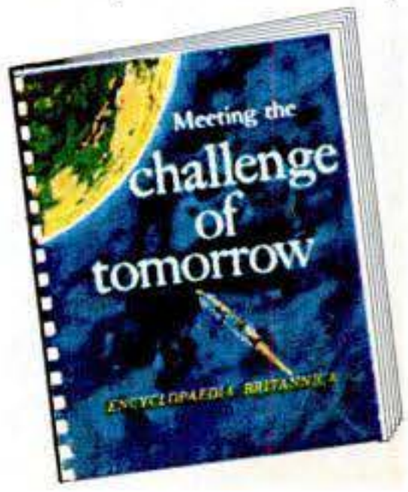

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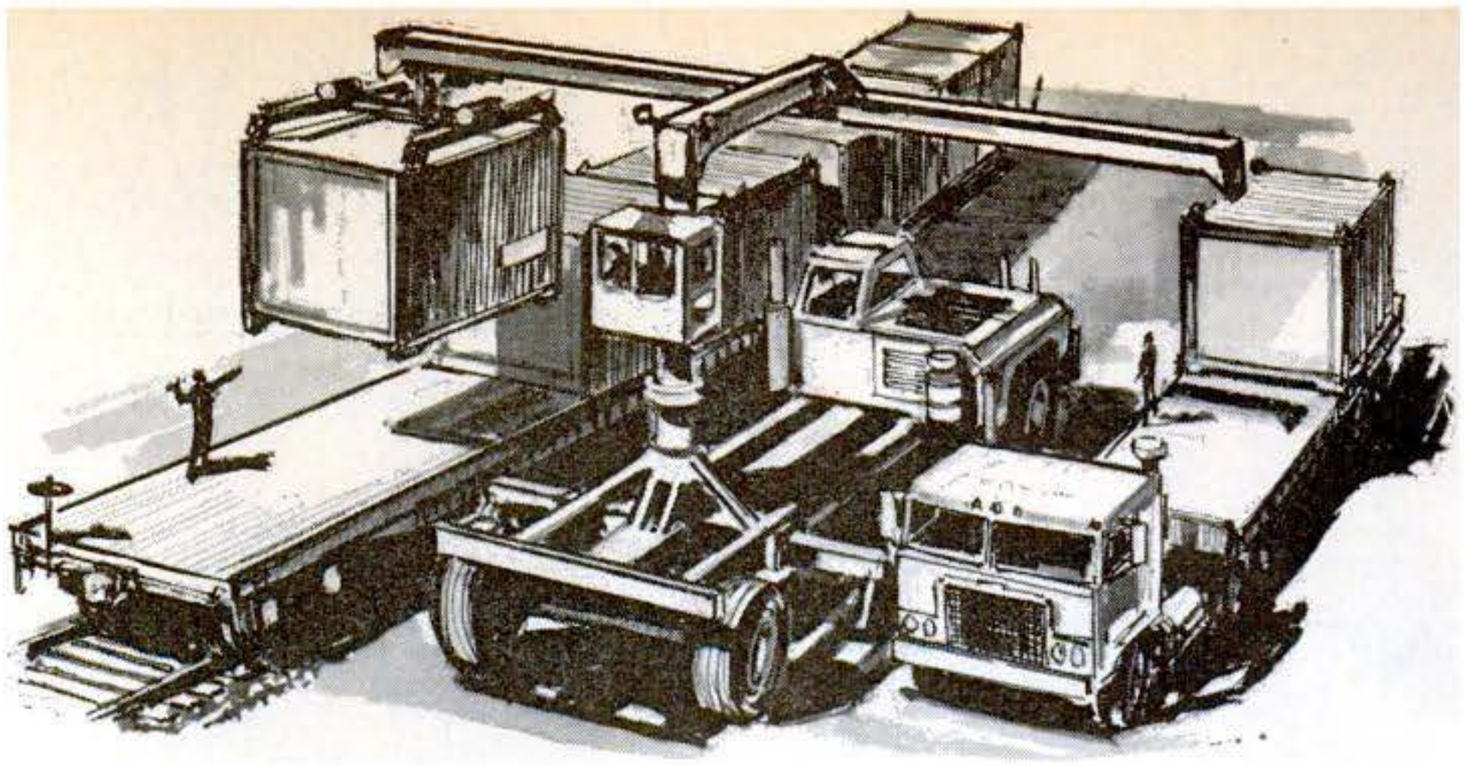
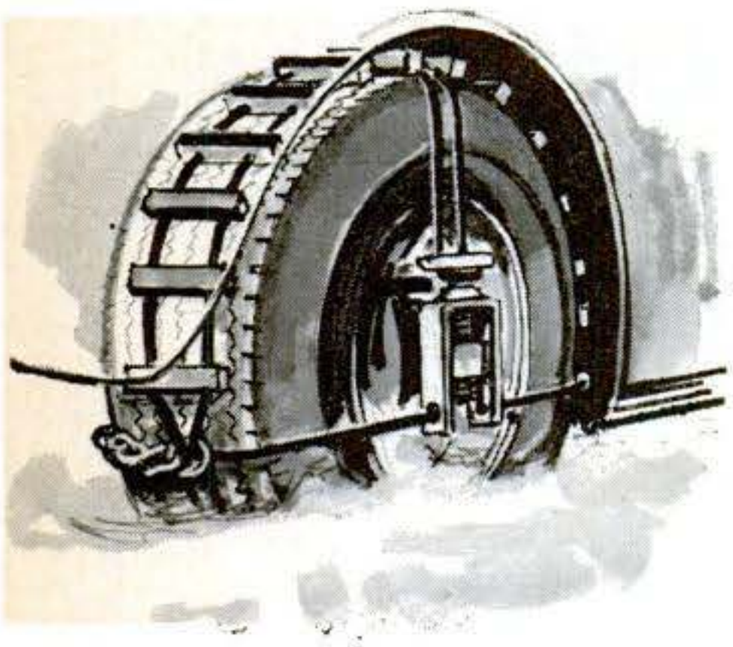
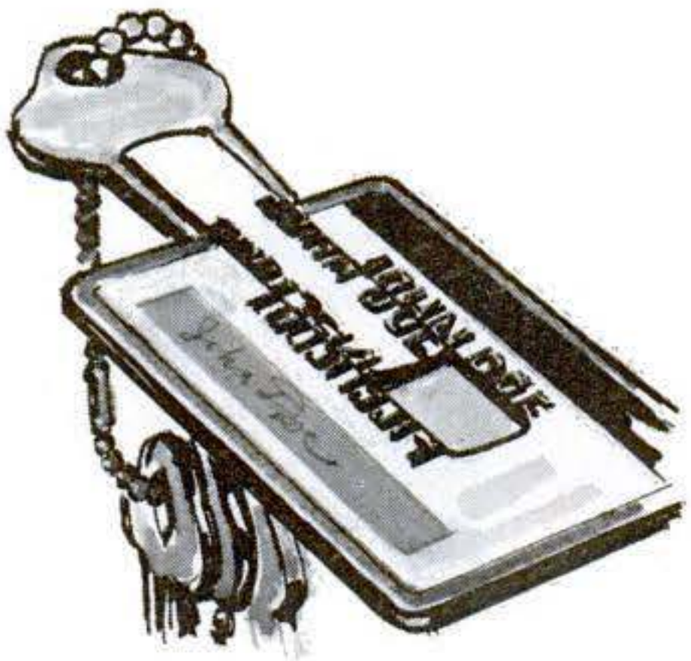


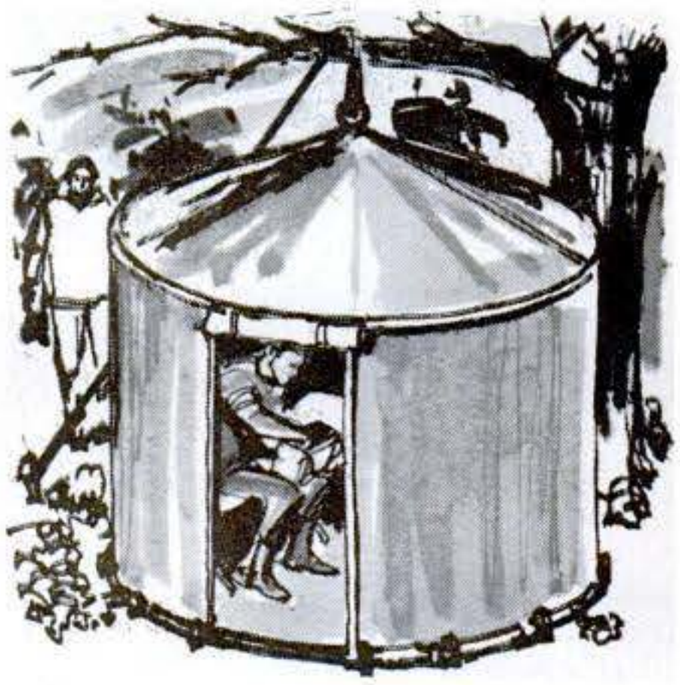
Van handler shifts containers. Most containerized cargo is moved by vertical lifters that straddle load and vehicle, taking cargo vans in sequence. This recently patented lifter would be more versatile, loading or offloading containers in any order on either side. Containers lowered flat onto the lifter's bed could also be transported faster than suspended cargo.



Tire clamp frees ditched car. Designed to fit part-way around—but not under—a tire, these wire-bound cleats could be mounted without jacking a ditched or mired car. The cleats would space two cables; slipped over the top of a tire, they would be joined by a chain and hook, tightened by a screw.



Key protects credit card. You wouldn't have to worry as much about a lost or stolen credit card if you carried part of it on your key ring. Made in two separate sections, one key-shaped, the other with matching slot, this card would have to be properly joined before it could be used—or misused.



Tree supports let-down tent. Needing no supporting pole, this tent could be erected quickly and would knock down compactly. Looped over a tree limb, a staked rope would hold the ringed top and several webbing strips spaced around it. Clip-on curtains draped over the staked webs complete the tent.

Apron keeps paint handy. Hooked onto your trouser belt, this convex shield would hold brushes and paint or varnish close at hand while leaving your hands free when climbing and moving around. Bowed outward, the rigid, drip-protecting apron would tend to resist tipping or spilling. Spring clips would keep brushes and bucket from being dislodged.

Skid totes your skis. A sled-like skid, with a protruding wheel for traversing hard ground, might make it easier to lug your skis, boots, and poles to or from a slope, or to walk them uphill. Strapped to this handled carrier, one or more ski sets could be conveniently pushed or pulled. A let-down rod would keep it propped upright. For long hauls, it could belt to car top.

The following patents have been issued on these inventions: **Container lift**—*No. 3,490,622 to R. F. Brackin, Holland, Pa.;* **Tire clamp**—*No. 3,511,292 to S. W. Guthrie, Terrytown, La.;* **Card protector**—*No. 3,505,954 to H. Projansky, Miami Beach, Fla.;* **Let-down tent**—*No. 3,489,305 to B. R. Hulin, Oklahoma City.;* **Paint apron**—*No. 3,493,152 to W. Ort, Wichita Falls, Tex.;* **Ski Cart**—*No. 3,504,921 to L. R. Osmond, Wichita, Kans.*

Copies of patents may be ordered, by number, from the Commissioner of Patents, Washington, D.C. 20231, at 50 cents each. To write to an inventor, if the address above is insufficient, address him (by name and patent number) in care of the Commissioner of Patents.

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To get a shot that really means something you go all out.

Your cigarette? Viceroy. It goes all out to give you all the taste you could ever want.

Viceroy gives you all the taste, all the time.

17 mg. "tar," 1.2 mg. nicotine av. per cigarette, FTC Report Aug. 71.

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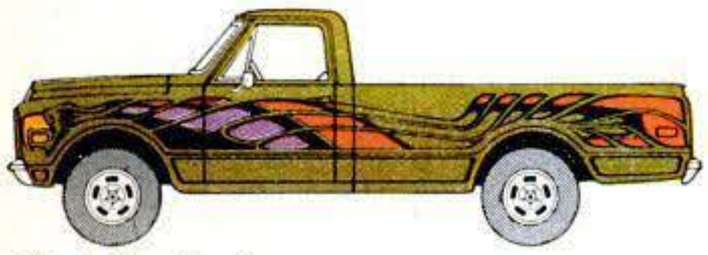
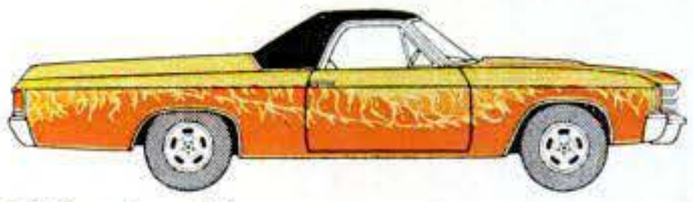
1972 Chevrolet. Building a

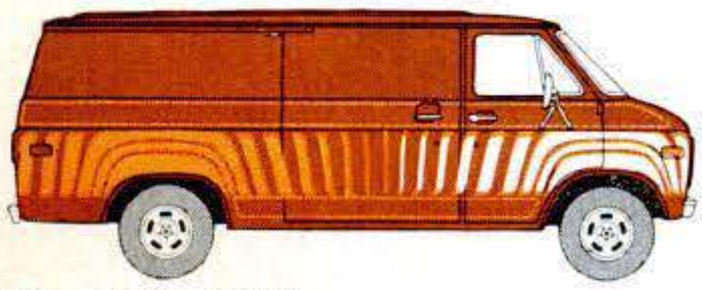
Blazer enthusiasts talk with fishing enthusiasts on the Lake Michigan shoreline.



Fleetside Eagle



El Camino Flame



Chevy Van Rippler

Suburban Sandman

This is Feathers.

First off, it's a for real Chevy Blazer. Our tough, roomy 4-wheel drive sport truck.

Now here's the put-on. That wild indianish body design is called, appropriately, "Feathers." It's a decal.

And your Chevy dealer can put it on any Blazer, Suburban or pickup at modest extra cost.

If "Feathers" doesn't tickle you maybe the "Sandman", "Flame" or "Eagle" decals will.

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better way to see the U.S.A.

Chevy trucks

One of five wild put-ons from Chevrolet.

Or the special El Camino "Flame" and Chevy Van "Rippler" designs.

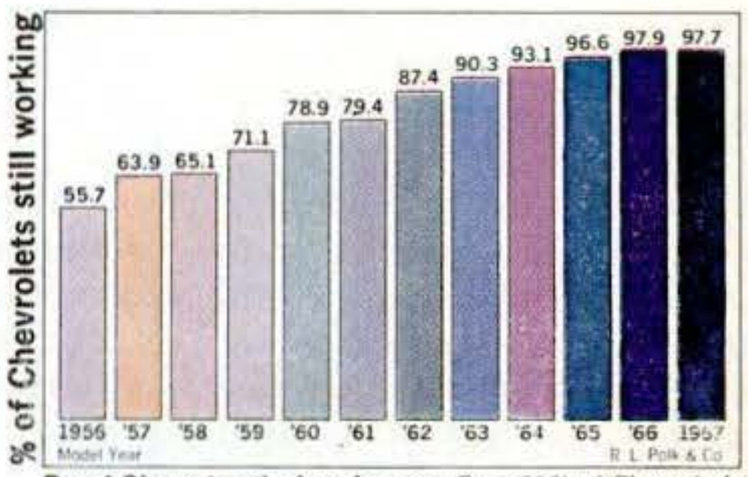
Chevrolet doesn't make the special mags, fat F60 tires and other heady paraphernalia that you see pictured above.

But your dealer can help you get the stuff.

People are going places and doing things in trucks that haven't been done before.

We think Chevy is the most dependable truck you can get into. People who don't believe us have to explain away this question: How come Chevy trucks last longer than all other trucks? So say the latest R. L. Polk figures.

We'd like you to believe this about a Chevy truck: we want it to be the most far-out truck you've ever owned. If that's the way you want it.



Proof Chevy trucks last longer. Over 55% of Chevrolet's 1956 model trucks are still in use. No other make has even half, based on latest R. L. Polk figures.

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Intermediates, clockwise from lower left: Chevrolet Chevelle Malibu, Ford Gran Torino, Plymouth Satellite, American Motors Matador.

PHOTOS BY A. J. HAND

How Good Are the '72 INTERMEDIATES?

Though alike in many ways, each of these cars has its own set of advantages and drawbacks

By **JAN P. NORBYE** / *PS Automotive Editor* **and JIM DUNNE** / *PS Detroit Editor*

Since the only completely new '72 car is the Ford Torino, we are starting our '72 series of auto tests by reporting to you how the Torino stacks up against the other intermediates. The Chevelle is the "oldest"—now in its fifth year without major change. The Matador was all-new for 1970. The Satellite dates from 1971.

These cars are called intermediates because they fall between compacts and standards in size. However, the Ford and Plymouth intermediates are now much closer to full-size cars than to compacts in actual length and weight. They are very nearly as big as the Galaxie and Fury of only five years ago—worth keeping in mind if you're hesitating between a standard car and an intermediate. In this test, we are not comparing the intermediates with their bigger brothers, but strictly against other intermediates.

All auto makers except American Motors now build their two-door intermediates on a shorter wheelbase than the four-door models. We tested the four-door versions, and our comments do not apply to two-door cars with the same nameplates.

All four intermediates are typical American sedans. They start, stop, ride, and generally operate without fuss. They are at their best cruising on smooth, straight roads. Their limited maneuverability at low or high speeds makes them less suited for winding country roads or city-and-suburban driving.

We chose our test cars equipped with the most popular options: small V8s and automatic transmissions (we do not recommend sixes for cars of this size, and the small V8s offer all the performance the average buyer seems to expect); power steering and front disk brakes (with power assist when standard); standard suspension and tires.

Chevelle Malibu. This is the only hardtop in the group (the others have strong pillars between front and rear doors). It has everything you expect in a GM car: smart styling, simple but attractive controls and instruments, well-coordinated interior design, good forward visibility, and a pleasant ride.

We particularly liked the new small steering wheel with the soft rim and quick steering response. It is easy to drive and gives you an impression of sporty handling, while in fact it was not the fastest in our handling tests. It understeers firmly, but the degree

Continued

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Presenting the case against rough weather:

the new Remington-Peters "Power-Pak."

100 pocketproof powerful "golden" 22 long rifle cartridges in a specially designed plastic case that really earns its keep... even when it's empty.

First, we made our 22 long rifle cartridges "pocketproof" with a special high-temperature lubricant that resists lint, dirt and grit. Now... thanks to a specially designed, golden, plastic package our 22s are just about everything-proof. The case keeps the cartridges securely in place and bad weather, moisture and dust out. And it was designed to fit neatly in the breast pocket of a hunting shirt or jacket. The lid of a "Power-Pak" slides back with a series of positive "click" stops ...you can dispense 5 cartridges (or 10 or 15 or however many you need) without fumbling with loose cartridges or packages that are more than a handful. And when the "Power-Pak" is empty, just flip the tray out, and you've got a great place to keep small spare parts, larger cartridges, trout flies, fishing lures, whatever needs keeping. We think the "Power-Pak" is right on target...worth looking for wherever you buy your ammunition.

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Great guns deserve great ammunition. We make both.

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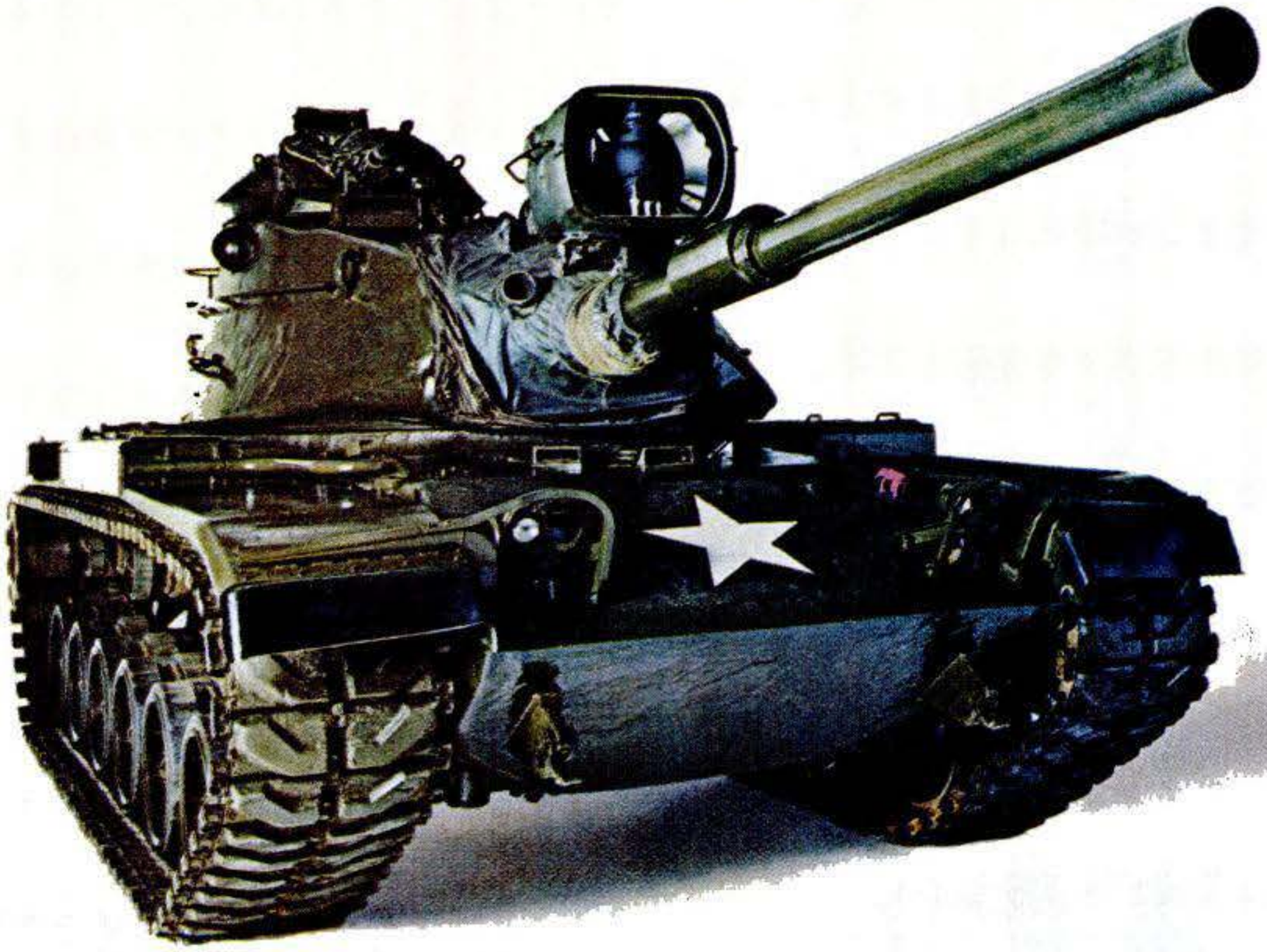

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Think enormous.

Small cars are making it. The M60-A1 is 27 feet long, 12 feet wide and weighs 52.5 tons, loaded.

Flashy colors are in. The M60-A1 gives you a choice of one. An odd, brownish green.

Gas economy is a must. At 3 gallons to the mile, it's not one of our best selling features.

But talk about power. The M60-A1 offers a 750-horse, 12-cylinder air-cooled engine and cross-drive transmission as standard equipment.

And maneuverability. The M60-A1 turns on a dime. Large, but a dime.

And ease of parking. Who's going to fight you for a spot?

The M60-A1. It isn't small. It isn't flashy. It isn't even economical.

It's just enormous.

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Today's Army wants to join you.

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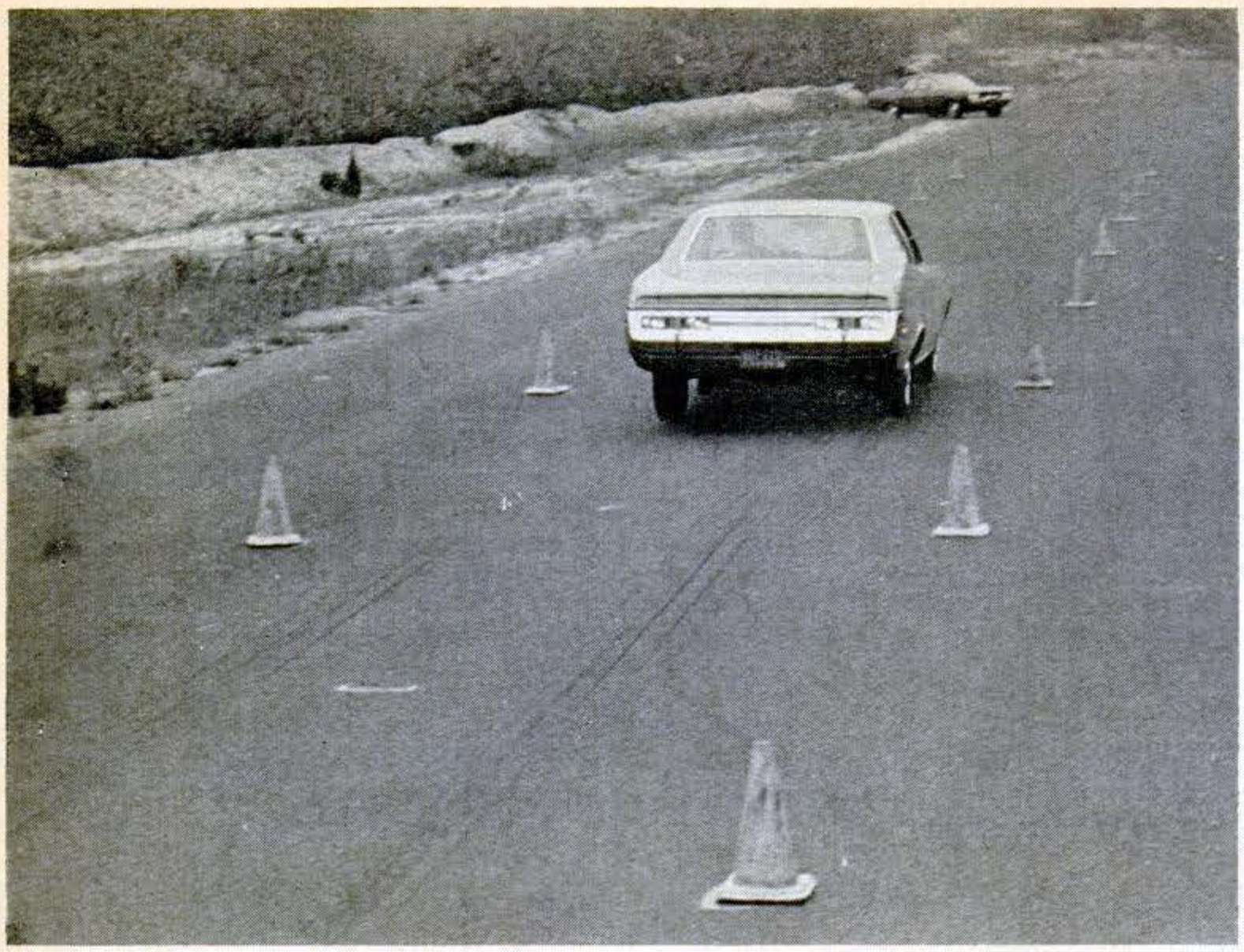
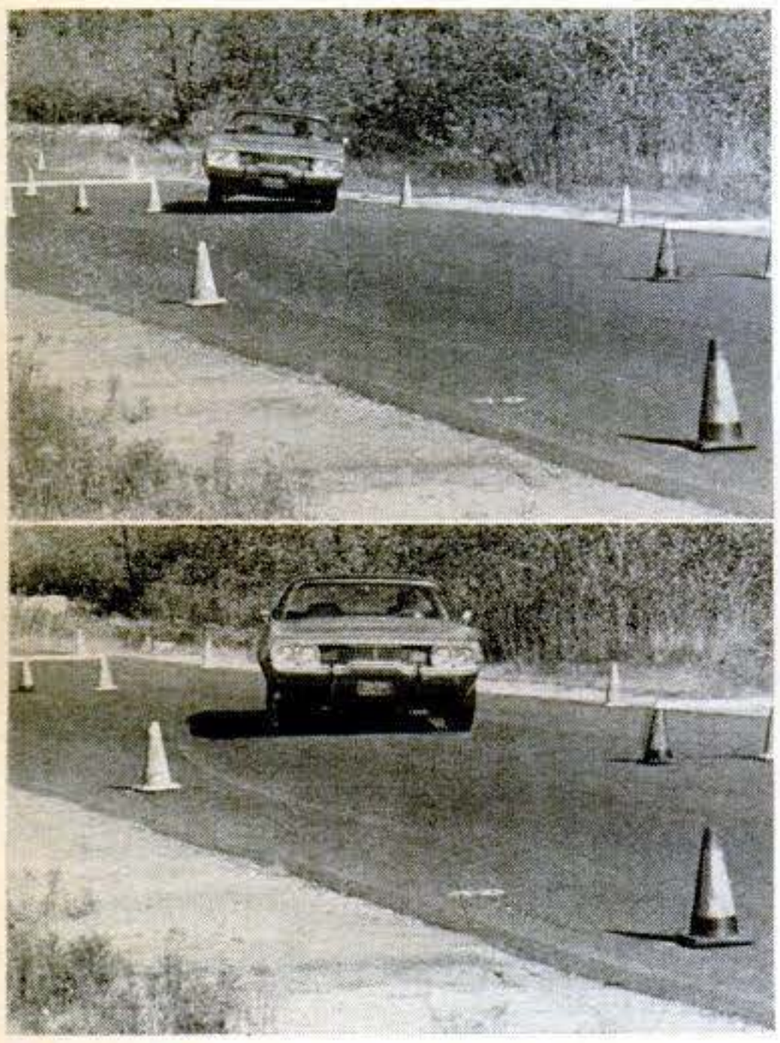
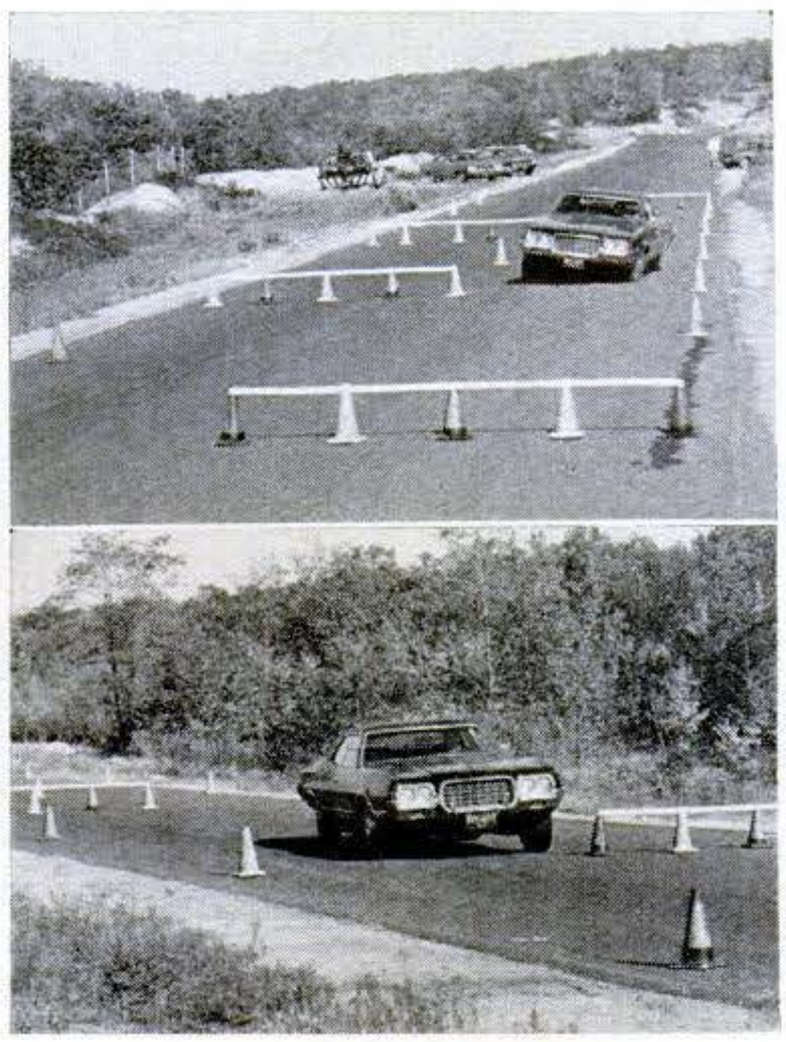


Matador made the shortest stop with warmed-up brakes—and also lowest pedal pressure.

Chevelle made the shortest stop with cool brakes, but faded somewhat when warmed up.



Plymouth takes double lane change with moderate roll, but oversteer begins to swing the tail when returning to the right (original) lane. See text for details.



Ford understees firmly all the way through the lane-change test, but retains its balance. High slip angles in front, however, kept the car's lane-change speeds down.

of understeer is not predictable within close limits when running tests with extreme lateral acceleration (0.6 to 0.9 g). Handling precision deteriorates as side forces on the vehicle increase.

The Chevelle proved surprisingly fast in acceleration—and somewhat disappointing in fuel economy. Its brakes were great when cool, and although they overheated and faded after warmup, stopping distance remained reasonable, even by today's standards. The power assist comes on very strong, and you may tend to overbrake. When you get used to the Chevelle brakes, they are easy to modulate, but many drivers prefer brakes with more dependence on foot pressure.

In the course of the Chevelle's development over the years, Chevy engineers have gotten all the design bugs out of it. At the same time they have also taken out a lot of the cost. This is fine, so long as the customer does not see any lowering of quality. But we did object to the front seat. The seat and backrest fail to give support where needed, and you can feel the hardware right through the thin padding.

The vent windows are a plus, for they function more effectively than all the fancy ventilation systems that have been designed by car makers to replace them.

Points to note: Antenna in windshield. Wipers cover most vital glass area. Rear visibility somewhat restricted. Underhood accessibility good (without A/C), but distributor is still in remote position against firewall. There is no interior hood release.

Gran Torino. The Ford is 250 to 350 pounds heavier than the other intermediates, and five to 10 inches longer overall. The interior is roomy, but the doors do not allow easy entry/exit. Passenger convenience has been sacrificed for an exciting roof line. The sharply raked windshield has resulted in a huge ledge over the instrument panel. Rear visibility is poor due to small glass area in the back.

The car has an extra 12 inches of unused space ahead of the radiator (not counting the space needed for headlights), adding a lot of sheet metal (and weight) to the car just for styling purposes.

The Torino's boulevard ride has been improved to a very high level, but handling has suffered. The nimbleness of the old Fairlane is gone; the Gran Torino goes into embarrassing wallows on winding roads at quite moderate speeds. It was the slowest in our handling tests, understeering to the point where directional

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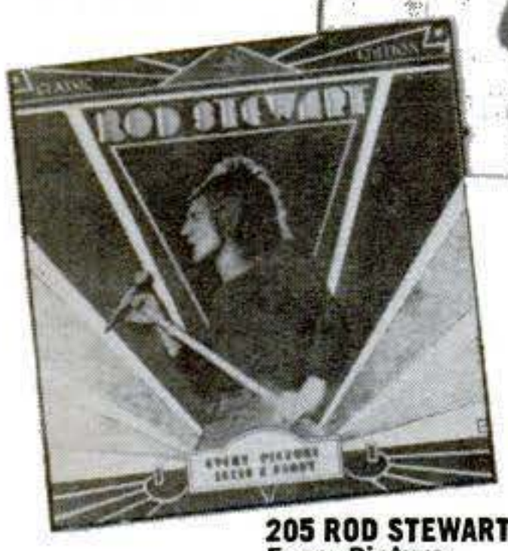
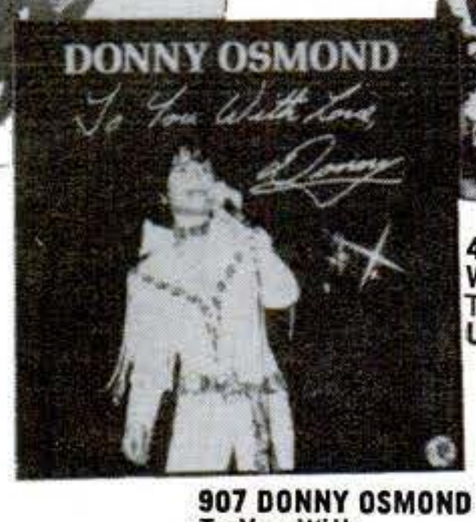
426 TRAFFIC, ETC. Welcome To The Canteen **UniAr** LP, 8TR, CASS

513 LED ZEPPELIN Atlan LP, 8TR, CAS



205 ROD STEWART Every Picture Tells A Story **Mercu** LP, 8TR, CASS



907 DONNY OSMOND To You With Love, Donny **MGM** LP, 8TR, CASS

823 THE WHO Meaty, Beaty, Big & Bouncy **Decca** LP, 8TR, CASS

035 JOAN BAEZ Blessed Are... (2 record set) **Vangu** LP, 8TR, CASS

777 GODSPELL Original Cast **Bell** LP, 8TR, CASS

354 101 STRINGS Webb & Bacharach's Million Sellers **Alshi** LP

708 HANDEL Water Music **Yorks** LP, 8TR, CASS

Compare and see!

825 NEIL DIAMOND Stones **Uni** LP, 8TR, CASS

660 MARVIN GAYE What's Going On **Tamla** LP, 8TR, CASS

423 FERRANTE & TEICHER Fiddler On The Roof **UniAr** LP, 8TR, CASS

100 THREE DOG NIGHT Golden Bisquits **Dunhi** LP, 8TR, CASS

824 ELTON JOHN Madman Across The Water **Uni** LP, 8TR, CASS

700 TCHAIKOVSKY 1812 Overture **Yorks** LP, 8TR, CASS

763 5TH DIMENSION Love's Lines Angles & Rhymes **Bell** LP, 8TR, CASS

275 CANNED HEAT Live At Topanga Corral **Wand** LP, 8TR, CASS

509 ROLLING STONES Sticky Fingers **RolSt** LP, 8TR, CASS

374 MARY LOU WILLIAMS From The Heart **Chiar** LP, 8TR, CASS

600 OCEAN Put Your Hand In The Hand **KamSu** LP, 8TR, CASS

380 ABBIE HOFFMAN Wake Up America! **BigTo** LP, 8TR, CASS

424 VIKKI CARR The Ways To Love A Man **UniAr** LP, 8TR, CASS

373 QUINTESSENTIAL EARL HINES **Chiar** LP, 8TR, CASS

405 BOBBY GOLDSBORO Watching Scotty Grow **UniAr** LP, 8TR, CASS

760 PARTRIDGE FAMILY Up To Date **Bell** LP, 8TR, CASS

827 CHER **Kapp** LP, 8TR, CASS

355 101 STRINGS Beatles' Million Sellers **Alshi** LP

614 SHA NA NA **KamSu** LP, 8TR, CASS

773 LAWRENCE OF ARABIA Original Soundtrack **Bell** LP, 8TR, CASS

665 JACKSON 5 Goin' Back To Indiana **Motow** LP, 8TR, CAS

826 SONNY & CHER Live **Kapp** LP, 8TR, CASS

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MUST YOU BUY A "MINIMUM" NUMBER OF RECORDS OR TAPES? HOW MANY?	12	6	12	10	12	NONE! No obligations! No yearly quota! Take as many, as few, or nothing at all if you so decide!
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MOODY BLUES—Every Good Boy Deserves Favour	Thres	5.98	2.04
THE DOORS—L.A. Woman	Elekt	5.98	2.04
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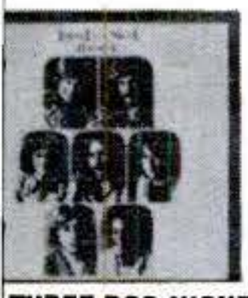

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mony
hi LP, 8TR, CASS

117 JAMES GANG
Live In Concert
ABC LP, 8TR, CASS

353 101 STRINGS
Love Story
Alshi LP

123 STEPPENWOLF
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270 DIONNE WARWICKE
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764 MOUNTAIN
Nantucket Sleighride
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264 GUESS WHO
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D JESUS CHRIST
PERSTAR
record set)
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774 5TH DIMENSION
Reflections
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770 THE PARTRIDGE FAMILY SOUND MAGAZINE
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119 GRASS ROOTS
Their 16
Greatest Hits
Dunhi LP, 8TR, CASS

370 JAMES TAYLOR &
The Flying Machine
Eupho LP

263 B. J. THOMAS
Greatest Hits Vol. 1
Scept LP, 8TR, CASS

817 THE WHO
Who's Next
Decca LP, 8TR, CASS

B. J. THOMAS
ndrops Keep Fallin'
pt LP, 8TR, CASS

908 ERIC BURDON & JIMMY WITHERSPOON Guilty
MGM LP, 8TR, CASS

308 JOAN BAEZ
Joan Baez 5
Vangu LP, 8TR, CASS

707 RCOA STEREO SYSTEMS TEST RECORD
Yorks LP

267 DIONNE WARWICKE
I'll Never Fall
In Love Again
Scept LP, 8TR, CASS

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ks LP, 8TR, CASS

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Matador steers its way with remarkable precision through the traffic weave, staying close to center line, with little slip.

Gran Torino tends to "plow" when thrown into severe turns at quite low speeds, and strayed from traffic-weave center line.

control becomes illusory under high centrifugal force.

The new Torino has a new brake system with front disks but no power assist. Pedal pressures were remarkably low with cool brakes. Stopping distances remained reasonable even after warmup, but on the whole the new brake system is a backward step from the Torino we tested two years ago (see panel showing previous test results).

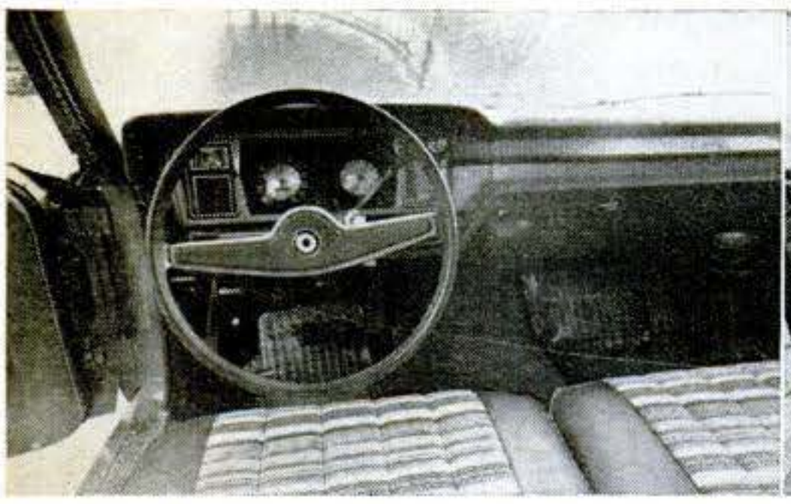
In terms of power and acceleration, the Ford came in a distant fourth in the group. Ford must have given up a lot of efficiency to get the Cleveland engine's emissions down to government limits. On the other hand, fuel economy was better than expected.

Points to note: No interior hood release. Poor trunk layout and spare-wheel position. Flow-through ventilation with high-level outlets doesn't do the job nearly as well as the vent windows used on last year's four-door Torino. Underhood accessibility much improved by removal of spring towers due to the car's new front suspension.

Matador. This is the highest, roomiest, and most practical of the intermediates. The rear-seat area is as large as on full-size cars. Generous glass areas offer good visibility front and rear. All aspects of the Matador's

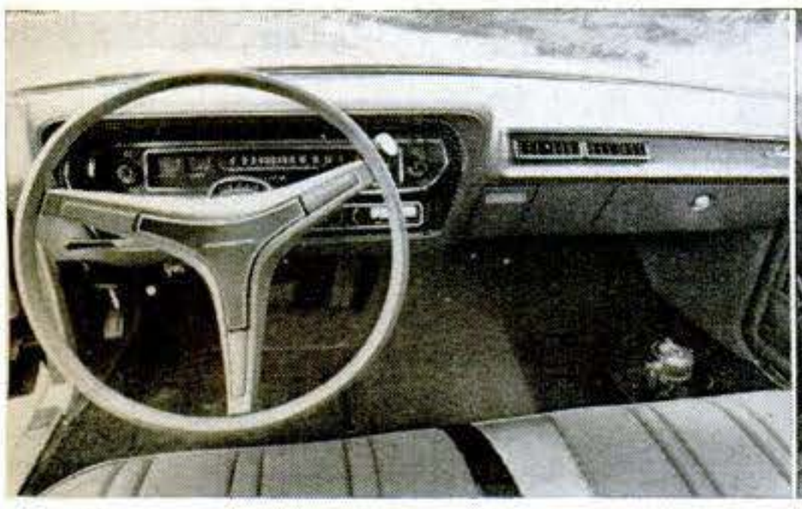
Continued

Test cars are lined up in preparation for gas-mileage test. Each car gets a one-gallon tank feeding into the fuel pump, with the main gas tank disconnected.



Matador instruments are grouped in front of driver, with high dash hood to prevent reflection in the windshield.

Chevelle has new VW-type steering wheel with soft rim, horizontal speedometer, symbol-marked small controls.



Satellite steering wheel is hard plastic. Instrumentation is more complete than in the other intermediates we tested.

Gran Torino persists with rim-blow steering wheel, and instrument panel is set a long way back from windshield.

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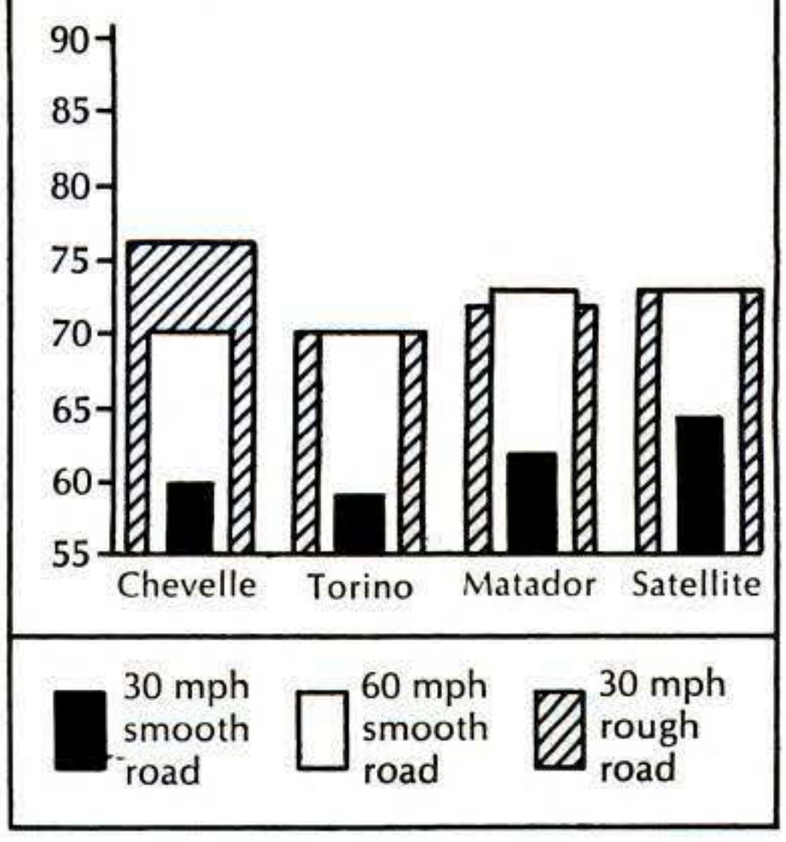

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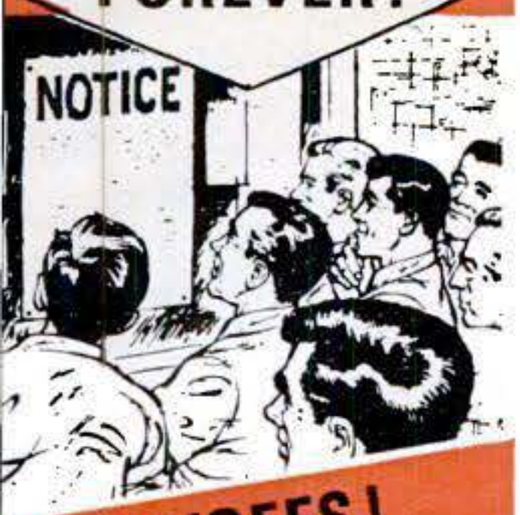

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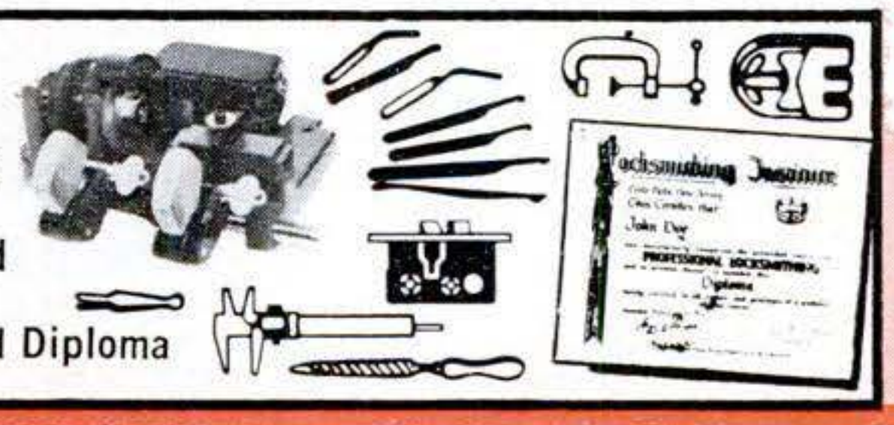

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How other cars have fared in our tests

CAR	'70 CHEVELLE 6	'70 TORINO 6	'70 SATELLITE 6	'70 REBEL 6	'71 VALIANT 6	PEUGEOT 504	VOLVO 144-S	AUDI 100 LS	'71 HORNET 6	'71 DODGE DEMON V8	'71 MERCURY COMET V8	'71 PONTIAC VENTURA II V8
Accel. 0-60	14.4	15.3	16.4	16.6	13.7	15.8	14.2	13.4	16.2	11.3	10.55	12.5
Accel. 0-80	29.0	32.6	33.2	33.6	28.5	36.0	28.3	24.1	29.9	20.4	19.6	23.7
Accel.25-70	16.1	18.5	19.7	20.2	18.2	20.2	14.7	15.0	18.3	13.0	11.55	14.3
Brake 60-0 (hot)	137.9	126.8	192.2	168.5	162.6	133.0	142.9	155.0	182.0	156.5	154.3	157.1
Lane change	51.4	53.0	53.0	51.5	53.0	57.25	51.45	54.6	53.0	49.9	53.0	54.5
Slalom	23.4	23.75	23.0	21.3	21.9	26.5	24.4	26.4	22.2	23.3	26.8	26.4
Fuel (mpg)	12.5	13.7	14.4	19.0	15.5	20.2	19.6	17.4	14.9	18.1	17.8	14.4
Noise (60 mph)	69 dbA	72 dbA	74 dbA	75 dbA	74 dbA	78 dbA	78 dbA	76 dbA	74 dbA	76 dbA	75 dbA	73 dbA
Price	$3,177	$3,142	$3,240	$2,963	$2,760	$3,317	$3,357	$4,019	$2,584	$2,970	$2,858	$3,081

design seem to stress function rather than appearance, yet the car has a neat, attractive interior and a contemporary exterior.

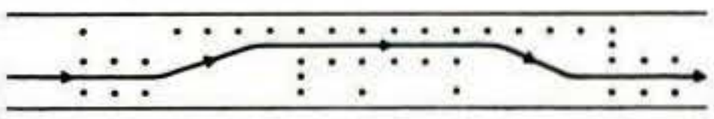
The '72 Matador is as modern as anything else in its class. American Motors' use of the superb Chrysler-built automatic transmission and the GM-produced Saginaw variable-ratio power-steering system are two important reasons for this. The Bendix brake system was chosen for quality

[Continued on page 123]

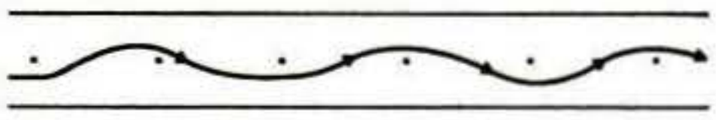
How PS tests cars—and what the tests show

Brake test shows a car's ability to stop from 60 mph without wheel locking. Test is first made with cool brakes, then repeated after 10 warmup stops from 60 at one-minute intervals with 0.5g deceleration. First test shows braking capacity, balance; the second, fade. Excessive pedal pressure indicates fade. Excessive distance indicates fade, incipient or partial locking, or combination of both.

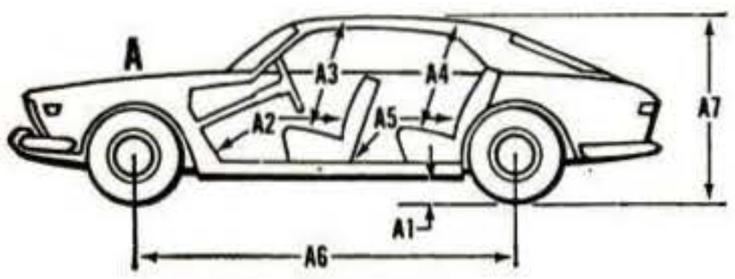
Acceleration test at 0-60 mph shows a car's ability to reach cruising speed from standstill. The 0-80 mph test shows its high-speed power reserve; 25-70 mph test simulates a highway merging situation. Cars with automatic transmission are tested in DRIVE.

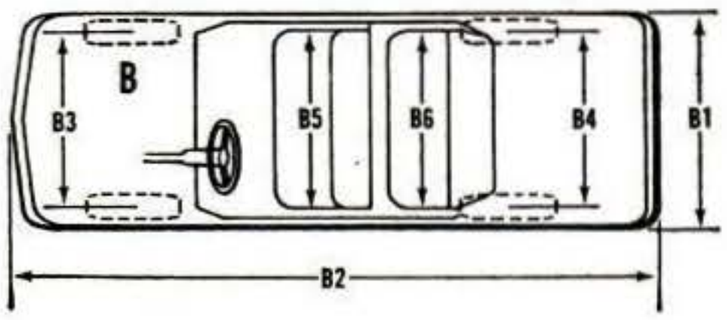


Two lane changes in quick succession show a car's ability to make an emergency maneuver at speed. Lanes are blocked 120 feet apart, and lane-change gaps are 60 feet long. Each car is put through test at increasing speed until its maximum is established.



Low-speed emergency maneuver test means snaking a car as fast as possible through pylons 48 feet apart. In both handling tests, times clocked by two stopwatches are converted to mph.





DIMENSIONS (inches)	CHEVROLET Chevelle Malibu	FORD Gran Torino Brougham	MATADOR by American Motors	PLYMOUTH Satellite Brougham
A1 Ground clearance	7.0	6.7	7.6	7.8
A2 Front leg room (max.)	42.8	42.2	41.8	42.2
A3 Front head room	38.1	38.3	39.6	38.5
A4 Rear head room	37.1	37.3	37.5	37.3
A5 Rear leg room (min.)	34.9	37.5	38.6	36.7
A6 Wheelbase	116.0	118.0	118.0	117.0
A7 Height	53.3	52.5	55.4	54.0
B1 Width	75.4	79.3	77.2	78.6
B2 Length	201.5	211.3	206.1	204.6
B3 Front track	60.0	62.8	59.9	59.7
B4 Rear track	59.9	62.9	60.0	62.0
B5 Front hip room	59.5	59.4	60.3	59.2
B6 Rear hip room	52.2	59.4	60.4	59.2
SPECIFICATIONS				
Engine type	OHV V8	OHV V8	OHV V8	OHV V8
Displacement (cu. in.)	350	351	360	318
Compression ratio	8.5:1	8.6:1	8.5:1	8.6:1
Carburetor	One 2-bbl.	One 2-bbl.	One 2-bbl.	One 2-bbl.
Hp (net) @ rpm	165 @ 4,000	161 @ 4,000	175 @ 4,000	155 @ 4,000
Torque (net) @ rpm	280 @ 2,400	276 @ 2,400	285 @ 2,400	260 @ 1,600
Transmission	3-sp. auto.	3-sp. auto.	3-sp. auto.	3-sp. auto.
Axle ratio	2.73:1	2.75:1	2.87:1	2.71:1
Tires	Uniroyal Fastrak Belted	Uniroyal Fastrak Belted	Goodyear Power Cush.	Firestone Sup-R-Belt
Tire size	E78-14	H78-14	E78-14	E78-14
Turn diameter (ft.)	42.0	41.7	39.0	41.4
Turns, lock to lock	2.9	3.7	3.3	3.5
Brakes	disk/drum	disk/drum	disk/drum	disk/drum
Fuel tank (gal.)	19	22.5	19.5	21.0
Trunk space (cu. ft.)	13.5	14.8	18.2	16.5
Liftover (in.)	26.6	28.3	27.8	25.2
Curb weight (lbs.)	3,535	3,797	3,540	3,455
TEST RESULTS				
Accel. 0-60 mph	11.4 sec.	14.3 sec.	10.3 sec.	12.6 sec.
Accel. 0-80 mph	20.45	27.6	20.4	22.55
Accel. 25-70 mph	11.75	15.65	12.05	14.25
Braking 60-0 (cold)	131 ft. 7 in.	135 ft. 8 in.	149 ft. 2 in.	159 ft.
pedal pressure	65 lbs.	60 lbs.	110 lbs	80 lbs.
Braking 60-0 (hot)	180 ft. 7 in.	173 ft. 4 in.	141 ft. 10 in.	151 ft. 4 in.
pedal pressure	200 + lbs.	200 + lbs.	55 lbs.	140-200 lbs.
Max. lane-change speed	54.5 mph	53.0 mph	56.3 mph	53.0 mph
Max. swerve speed	23.9 mph	21.8 mph	24.6 mph	25.3 mph
Mileage (constant 45 mph)	15.445 mpg	17.363 mpg	18.782 mpg	15.955 mpg
Price (basic)	$3,047	$3,248	$2,792	$3,003
Price (as tested)	$4,094	$4,308	$3,790	$4,255

Satellite's turn signals are set in grille, inboard of headlights. Hood is unlatched.

Chevelle is only intermediate with single headlights, outboard turn signals.

Gran Torino's turn signals are integrated in its front-bumper design.

Matador carries its turn signals in protected position below the bumper.

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I have a battery problem. In a week of driving my 1969 302-c.i.d. Mustang to and from work—about 100 miles total—the water level in the battery drops from full to down below the cells. I just bought a new Diamond heavy-duty battery, but the water goes dry just like in the old one. Can you help?

AL BARLOW, Lakeland, Fla.

I believe your system is overcharging, causing the battery to get hot, and evaporating the water. In any case—except for a hole in the battery—the only way that the water can disappear is by evaporation from the cells.

At normal temperature after stopping for a few minutes, my '67 Chevy Caprice will not restart because the starter will barely turn the engine over. I have to wait until the engine has cooled down. My daughter's '66 Chevelle with a 286 engine has the same problem.

L. A. JAROSH, Yuba City, Calif.

Battery cables, especially the kind with spring locks (rather than bolts) can cause this. There's also the possibility of a high draw from the starter motor when the engine's hot. All these and other possibilities can be checked very easily with equipment found in most garages—but these checks should be made with the engine hot.

After losing all my coolant through a busted radiator hose on my '69 Ford 390 V8, I decided to change all the coolant hoses. All went fine until I reached the two-inch-i.d. hose between the water pump and intake manifold. I just know it will be the next to go. Is there any way—short of removing the intake manifold or water pump—to change this hose?

S. W. VORDENBAUM, Fort Ord, Calif.

No. But as a rule that hose outlasts the others by quite a bit. Anyhow it really isn't such an awful lot of work to slide the pump up to change the hose.

My father and I have a running argument concerning my 1965 V8 Mustang 289 and the set of Goodyear Polyglas F70-14 tires on it. Things are breaking down on the car and he blames it all on the tires. My contention is that it's only because the car is old and I frequently use the expressway at high speed. Am I doing damage to the car by using these wider-than-normal tires on my car? Do you recommend going to a heavier front-end suspension to compensate for the extra wear that I may be putting on the present front-end suspension?

PAUL A. MARTIN, Munster, Ind.

I doubt if the tires are your problem. I'd guess that normal wear and tear is catching up with the car. Your father does have a point—but rather a small one. As for beefing up the front suspension, I don't think that's really necessary, unless since you changed tires you have taken more out of the car in cornering. If this is the case, then the suspension should be brought up accordingly.

Since the day I bought it, my 1971 Pinto with two-liter engine and automatic transmission has accelerated poorly from slow speed and standstill. The transmission spins in drive until the speedometer needle reaches about 17 or 20 mph, then it goes into gear and the car moves. I've been back to the dealer and Ford customer relations. But the answers are always: There's nothing wrong; that's the way it's supposed to be; get used to it; or the engine's too weak! Any suggestions?

B. STODSKY, M.D., Chicago, Ill.

Try driving two or three Pintos just like yours—from friends, car rentals, or dealers. If they all perform like yours, either swap or get used to it. If they perform as they should, get that "Ford Listens Better" telephone number and start raising hell.

Will the better-brand oils deteriorate if left on the shelf unopened for two or three years? If I planned to keep a new car for its useful life, would it be a sound idea to buy enough oil to last 100,000 miles so as to keep the same brand and type in the engine? Do the "honey" petro additives actually help an engine and increase its life?

W. R. JACOBS, Birmingham, Ala.

I don't think unopened oil deteriorates in that length of time. But as time goes by, improved technology makes the product better, so maybe halfway through that 100,000 miles you might miss a better oil for your engine. If "honey" additives are good I've missed the deal. I believe they give temporary relief to a worn-out engine under certain conditions. But I'm against using them in an engine that's in good shape.

The article "Small Buses—the Most Versatile Wagons" [July] told about severe brake problems in the Ford Econoline. In addition to the problems mentioned, my 1969 Econoline also has a severe brake fade when braking hard from 70 mph. After slowing it from 70 to 40 mph the brakes fade to almost nothing. I had the drums trued and installed Grey Rock Premium linings, but the problem still exists. Is it possible to have larger brakes installed?

NORMAN FOLKER, West Allis, Wis.

Yes, it's possible—but it would be a custom job and an expensive one that should be done only by a mechanic who is also a brake engineer. I wouldn't attempt it. Your best answer is a swap job before you get hurt. I believe you'll be happier with H-D disk brakes. Although they cost more and last less in total miles, they're particularly good against fading.

Using regular gasoline, I get poor performance and only 11 mpg in my 1971 LeMans Sports with 350-c.i.d. engine, full power, and dual exhausts. Friends and a mechanic suggest a methanol-and-water solution which is vaporized and drawn into the PCV hose with a T fitting. They claim it increases gas mileage and performance. Are add-on methanol systems beneficial?

HERSCHEL CAST, Little Rock, Ark.

This deal would do something along the lines they suggest. But if we run down all the ramifications to the end, you come up the loser.

My 1967 Chevrolet with 327-c.i.d. engine burns oil at 4,300 rpm. The compression is 150 p.s.i. in all eight cylinders and the plugs burn clean. I've checked—and even disconnected—the PCV valve and the breather leading from the crankcase to the oil cleaner. But it doesn't use oil until 4,300 rpm. This has gone on since the car was new, though I followed the usual break-in procedure for the first 500 miles. Do I need breathers on the valve covers for more ventilation?

WAYNE KIEKENBUSH, Salem, Wis.

If you have no leaks, and everything else is as you say, I believe that at that high rpm your valves are buried in oil, oil is being pulled down the valve stems past the seals and it is being burned. The fix would be good valve seals—and cut down the oil supply to the top end.

Would an electronic (solid-state) ignition system be worth installing? What are the advantages and disadvantages?

JOE NUCKOLLS, Greensboro, N.C.

Depends on what you're looking for. If you want easier starting (especially in extreme weather), longer plug life, less maintenance, and better top-end performance, the answer is yes. That is, if the cost doesn't scare you. If you're after better mileage and more power, you'll be disappointed. PS

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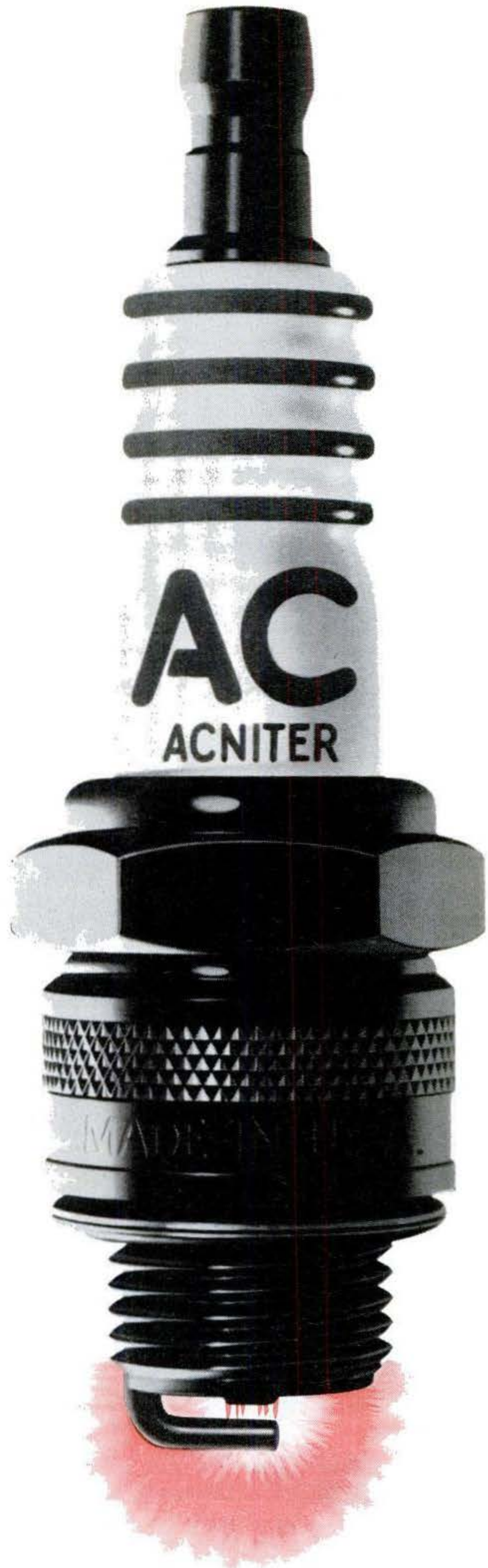

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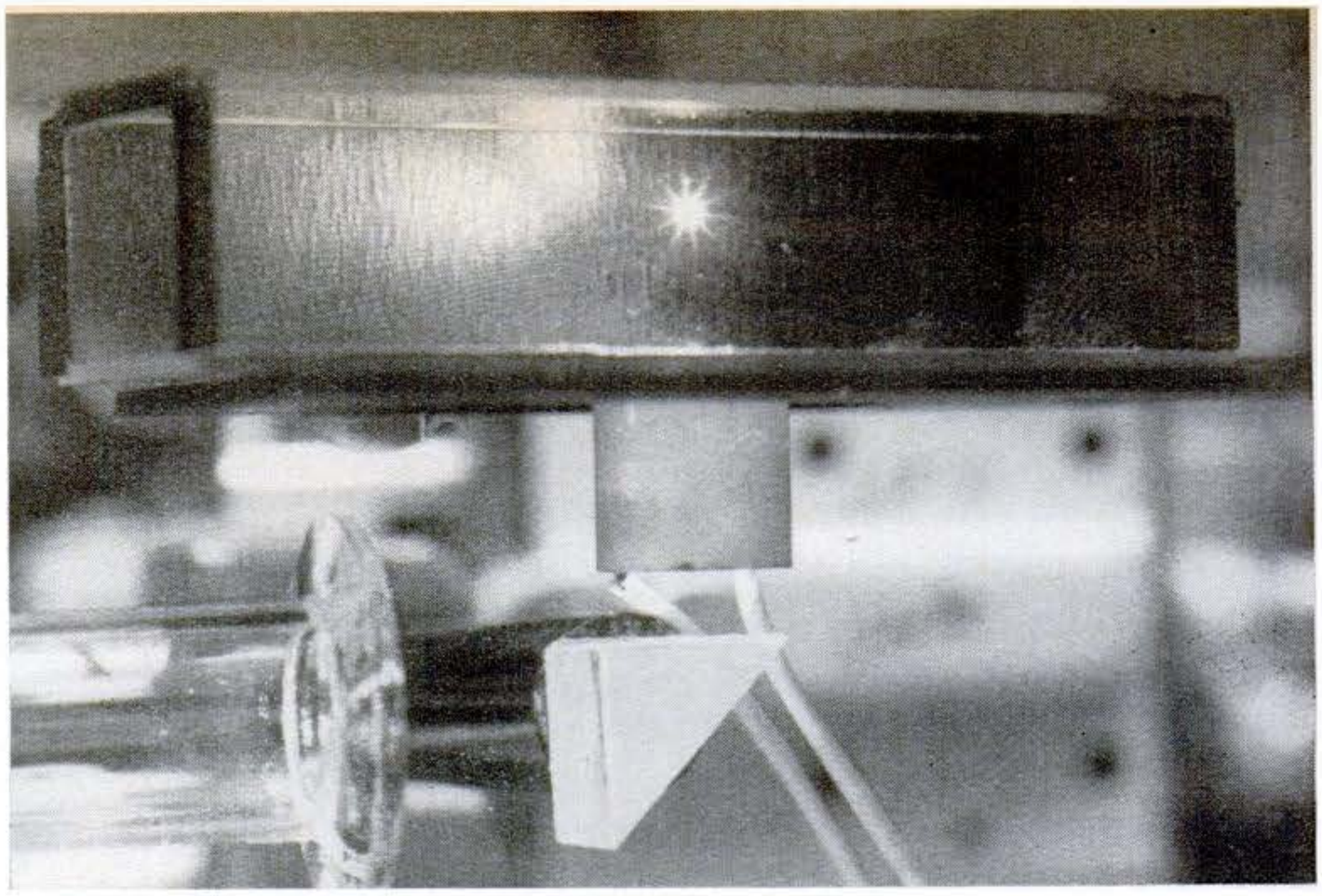
Science Newsfront

Last-minute news and notes to keep you up-to-date

By ARTHUR FISHER



Scientists suspend matter in space with laser light

In an historic experiment, physicists at Bell Labs have achieved the first reported case of optical levitation—lifting tiny glass spheres from a glass surface and keeping them floating in space for several hours with a light beam. Arthur Ashkin and Joseph Dziedzic focused the light from a quarter-watt argon laser on a glass bead about one-thousandth of an inch in diameter—the kind used in traffic-sign reflectors—resting on a glass plate. Radiation pressure from the laser light lifts the sphere, seen here as a twinkling star, to a point where the pressure just equals the force of gravity, and keeps the particle suspended in an "optical bottle." It may be used in communications to measure scattering loss caused by particles.

Doubled talk goes straight

Slowing down or speeding up recorded speech has been used as a party gag for years. The resulting shifts in pitch, down to a slow, agonized moan and up to a high, rapid quacking, are just plain funny, if virtually unintelligible. But serious researchers have been looking for a way to control speech speed without shifting pitch, because "compressed" or speeded-up speech offers great advantages in efficiency. Devices have been developed to do the job, but they have been bulky and expensive.

Now Cambridge Research and Development Group has produced a Variable Speech Control in the form of a tiny solid-state module, smaller than a postage stamp, that can be incorporated in conventional phonographs and tape or cassette players for less than $10 a unit.

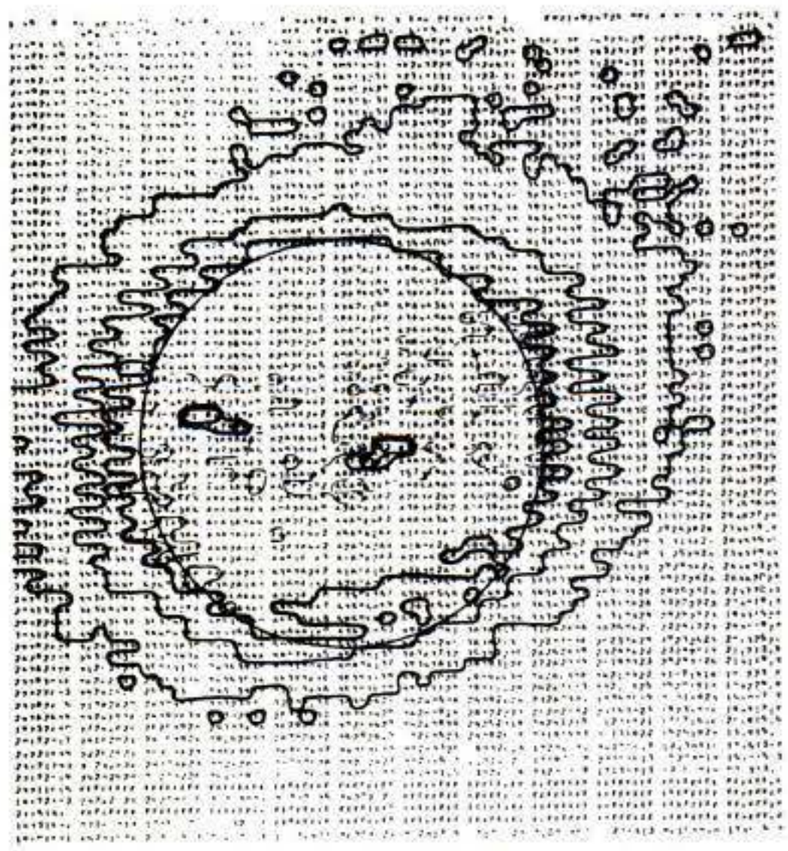
By twisting a knob, the listener will be able to control the rate of speech from 90 words per minute to 500—with no amusing sound effects. The average speech rate is 175 wpm, but the blind, or students, or businessmen, can learn to "speed-listen" at about 400 to 500 wpm. By contrast, the average reader makes 250, the Braille reader 60-90, readers of large-type books 125.

TV time signal is boss

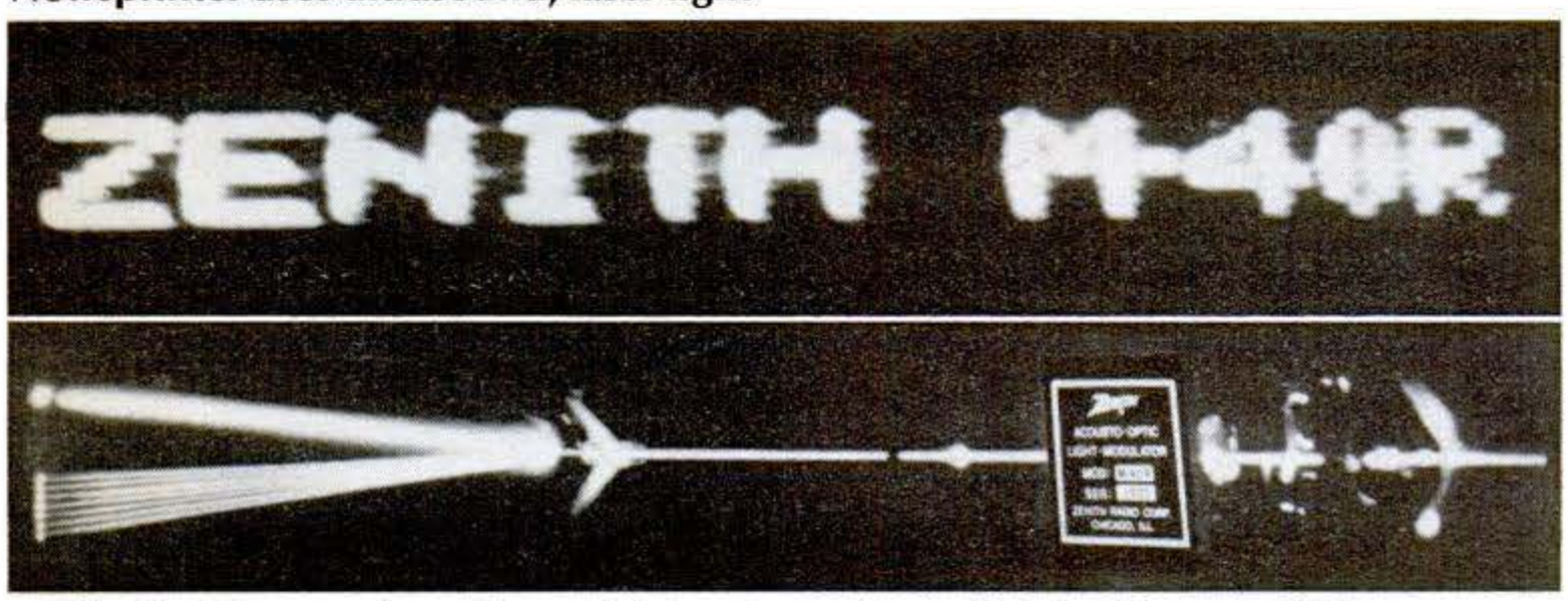
Your next TV may have a built-in circuit that will give you the time with accuracy of more than a millionth of a second. The system was demonstrated by the National Bureau of Standards, transmitting over the three TV networks to specially adapted sets in the Denver area. The time signal is transmitted along with the TV picture, and continuously regulates an electric clock even when the set is off.

A new picture of the sun

This computer readout is actually a portrait of the sun made in ultraviolet light. It comes from the Orbiting Solar Observatory launched in late September. The picture, received at NASA's Goddard Space Flight Center at Greenbelt, Md., shows the approximate size and position of the visible sun by the smooth circle. The squiggly lines define regions of differing ultraviolet activity in the sun's inner corona, which stretches in this picture to a distance of about 864,000 miles from the sun's center. The two "eyes" that turn the portrait into a man-in-the-sun are areas of unusually violent solar activity.



Newsprinter uses ultrasound, laser light



The Zenith acousto-optic modulator shown immediately above could be used as part of a newsprinter that would transform inputs from computers or news wires into an incredible 100,000 characters per second. The device splits a laser beam into a fan of seven ultrasound-modulated beams, which generate the characters seen above.

Moon's magnetic field

One important lunar question appears to have been answered by a small satellite placed in moon orbit by Apollo 15. Based on preliminary analysis of data from a magnetometer aboard the 80-pound craft, scientists at UCLA conclude that a magnetic field powerful enough to be detected 70 miles up envelops the entire moon. Prof. Paul J. Coleman Jr. reports, however, that the field is not uniform, and that it is much "bumpier" over the rough, crater-pocked far side of the moon than over the near side, which is filled with the huge,

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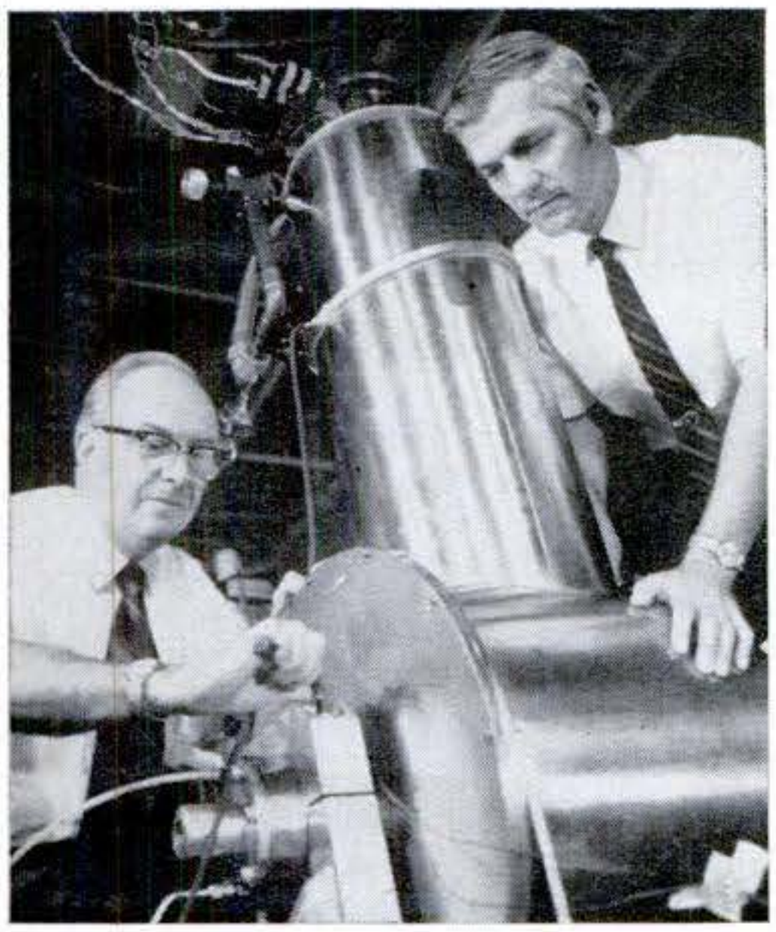
smooth mares. Before Apollo, most scientists thought the moon had no magnetic field at all. Confirmation of an overall, strong field gives new ammunition to defenders of the "hot moon" theory—the idea that the moon once was—and may still be—a geologically active body [see "How Apollo 15 Changed Our Ideas About the Moon," in this issue].

Superconducting DC generator

A marriage of space-age cryogenics technology with 19th-century electromechanics has spawned an impressive offspring: a 150-kw/DC four-disk generator with half the size and weight of a conventional unit of the same output. Engineers at General Electric, in a project sponsored by the Naval Ship Systems Command, had the job of reducing the weight and bulk of propulsion systems for the U.S. Navy. They knew that one of the simplest and most compact forms



of DC generator was the acyclic, or homopolar, machine invented in 1831 by Michael Faraday. It consisted of a rotating copper disk and a horseshoe magnet. But such generators have not been widely used because of their low voltage and high amperage, which requires very efficient conductors and brushes.

The GE engineers overcame this handicap by grafting superconducting coils and liquid-metal contacts onto Faraday's design. The superconductive coil, the field winding of the generator, is operated at −450 degrees F, at which point it has zero electrical resistance. It can thus develop a tremendous magnetic field. And instead of the conventional solid current collector, the engineers prescribed a liquid-metal alloy of sodium and potassium. The liquid metal fills the narrow gap between rotor and stator, passing electricity between the stator and four disks, and has 30 times the capacity of conventional brushes.

X-ray exposure

The radiation Americans receive from medical X rays—now the highest in the world—can be cut in half with a new intensifying screen developed by Lockheed for the AEC. If a special green-sensitive film were used, the reduction would be 20 times. The screen uses a new rare-earth phosphor. PS

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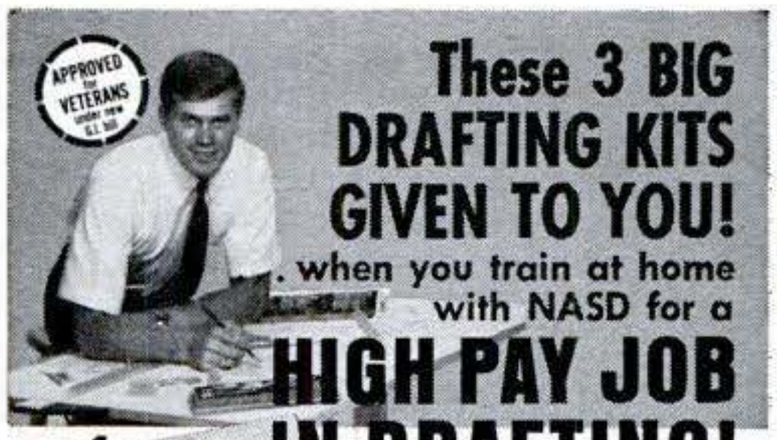

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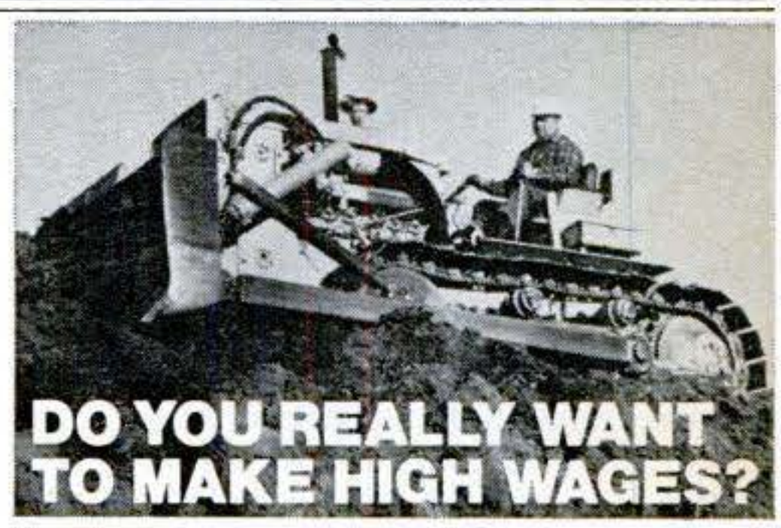

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Look and Listen

News, comment, and opinion from the world of home-entertainment electronics

By C. P. GILMORE

The sound of fun

A few weeks ago I received an invitation to see and operate a new electronic synthesizer called the Synthi AK, built by Electronic Music Studios, a British firm. The music synthesizer (pictured above) is basically a complicated combination of oscillators, wave shapers, switches, keyboards, and other parts that can produce any kind of sound you can imagine. All packed in one compact suitcase (the picture shows two identical units).

The device, at a hefty $1,000, is still far cheaper than anything else available that does anywhere near the same job. The company originally designed the synthesizer for professional users—electronic-music composers and jazz musicians. But oddly enough it's catching on with hi-fi buffs who have apparently run out of other equipment to buy. So a team has been traveling around the U.S. talking hi-fi stores into stocking the synthesizer.

Ordinarily, I wouldn't predict brisk sales for such a far-out item, particularly at that price. But after fooling with a synthesizer for a half hour, I'm not so sure. Coaxing sounds from this electronic-music machine is absolutely fascinating. If your local hi-fi store has one, by all means try it.

High fidelity—a new definition?

The music business is changing. And high-fidelity equipment changes with it. Yet the more it changes, the more it stays the same. Let me explain.

When I built my first high-fidelity amplifier in 1946, the game in speakers was efficiency. Low-distortion power was expensive, and the speaker had to make the most of the limited electrical energy available.

But as time passed, amplifiers were developed that could crank out lots of clean audio. That led to the Age of the Acoustic-Suspension Loudspeaker. The new speaker produced really low bass and smooth frequency response from a small box. It was inefficient, but with the powerful new amplifiers that didn't matter much.

But a few holdouts continued to preach the virtues of the high-efficiency speaker, including one of the oldest and most respected names in speaker making, James B. Lansing.

And that brings me to the point of this story. I recently spent a day as the guest of JBL at the Record Plant, a magnificently equipped studio in midtown Manhattan where many of today's top hit records are produced by a fantastically complex process.

During the day, I witnessed the evolution of Don McLean's new record, "American Pie." First I heard the original two sound tracks—one McLean's voice, the other his guitar. They had been taped with two mikes, on separate tracks of a 24-track recorder.

Later groups of musicians had been brought into the studio and, listening to the guitar and voice tracks on headphones, had played along in sync and recorded drum, piano, string, horn, and other parts on other tape tracks.

Then the real work began. The recording engineer and the producer of the record began playing back the tracks one by one. With a 24-channel control board, they shaped each instrumental sound—for instance, filtering out highs from the bass drum and lows from the snare to increase their sense of separation. Adding echo to the tambourine. Brightening the guitar sound.

With a marvelous device called a pan pot, they moved each instrument from left to right until they found just the right spot for it in the stereo perspective. Special tricks were added to perk up aural interest even more: The piano was mixed so that when the pianist runs up the keyboard and back down, the sound zooms from left to right and back. This is typical of how records are made these days.

All of this may not seem to have much to do with speaker efficiency, but it does. In fact, said Larry Phillips of JBL, this blend of art and technology leads to an entirely new definition of high fidelity. (If you sense a commercial on the way, you're right.)

In the early days, the primary goal of high fidelity was to reproduce the original sound of a performance as faithfully as possible. And to the high-fidelity industry, the only music worth taking note of was music performed by a symphony orchestra, opera company, string quartet, or the like.

The acoustic-suspension speaker was well suited to recreating this classical music in the living room. But today, only three percent of the U.S. record business is in classical music. Most of the rest of the money spent goes for records of the sort I saw being assembled.

The product produced is the music of visceral involvement. Physiological tests show that sounds of the type produced by guitars, bass drums, and other instruments at commonly used playback levels produce sound-pressure levels that dilate capillaries, increase heart rate, and have other physical effects. Listening to such music is a *feeling* as well as *hearing* experience.

Mr. Phillips claims that low-efficiency—and particularly air-suspension—speakers simply can't produce either the transient response or the sound levels to satisfy these requirements. And then he made this powerful claim: According to Mr. Phillips, every major recording studio in the world except one uses JBL speakers as monitors. That one is Columbia. And, he says, Columbia is now switching to JBL.

That leads to the new definition of high fidelity now being promoted by JBL. The sound of 97 percent of currently produced records never existed in nature. That sound, as shown so clearly in the demonstration I witnessed, is as much a manufactured product as the speaker over which it is played.

The only "original sound" was the one shaped on the control-room loudspeakers—not the collection of actual sounds heard in the studio. So the goal of playback equipment is not to reproduce the original sound of the instruments, but to reproduce the sound heard on the control-room speakers.

The argument has a large element of internal logic. And JBL is now beginning an aggressive advertising campaign to sell this story. It will be some time before its full effect can be judged. But it is at least possible that we will see a strong new trend in the high-fidelity field—back to high-efficiency speakers.

As I said, the more things change, the more they remain the same.

Four-channel progress?

The big question about four-channel sound has been this: Can we develop a standard matrix system, or will there be a long, bloody battle that will confuse prospective purchasers and set back the whole four-channel movement?

A short time ago, I began detecting clues that cooperation might be near. Instead of harping on the differences among various matrixes, I heard several company spokesmen emphasize similarities instead. The general message: Most matrix decoders are more alike than different; most are largely compatible. The one exception is the relatively incompatible CBS system.

Now, on top of all this friendly talk comes a new development. Larry LeKashman, president of Electro-Voice, has announced a new super decoder that he says will automatically decode any

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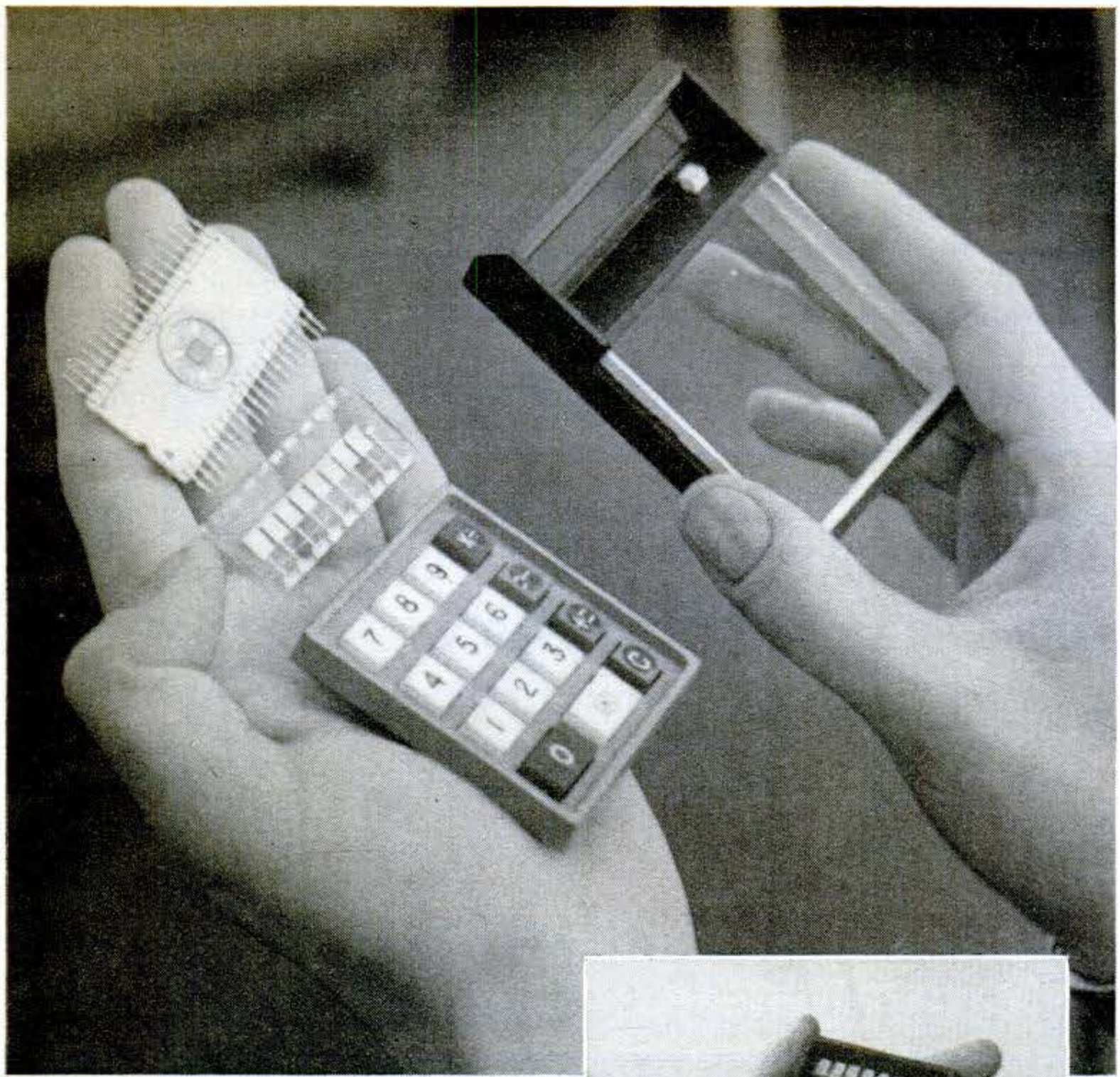

Four-function unit adds, subtracts, multiplies, and divides. At right, a wooden mockup. Major components include a 40-pin, two-chip ceramic package, an eight-digit liquid-crystal display, and a keyboard with associated printed-circuit board.

Look—A $100 Mini-Calculator!

A pushbutton bombshell is scheduled to explode this month: a compact, fully automatic electronic calculator priced around $100. The 2¾-by-⅞-by-3½-inch, eight-ounce calculator should be the first "personal-use" unit priced low enough to tap the huge market of students, salesmen, technicians, housewives, and income-tax payers. To date, calculators with similar capabilities have been discounted to about $200 [PS, June '71, p. 74].

At Ragen Precision Industries (9 Porete Ave., North Arlington, N.J. 07032) two months ago, I held the calculator's electronics in my hand; some components were still being engineered for the production line. But RPI's president, I. I. Lopata, was confident that announced deliveries of 20,000 calculators to Alexander's, a New York department-store chain, could begin in January.

The 7/32-by-5/32-inch liquid-crystal readouts [PS, Oct. '71, p. 73] will show the first eight significant digits in the answer, with the floating decimal point automatically placed. Later models may have a switch to display eight additional digits—separately—which the 0.2-inch-square, large-scale-integration chips compute anyway.

How do they shrivel both size and price? RPI's semiconductor division will make both the displays and complementary metal-oxide semiconductor (C/MOS) chips. This combination needs only a minute trickle of current (10 micro-amps), so the calculator can operate one year on two tiny, specially designed six-volt batteries—the only major component not made by Ragen. You'll know it's time for new batteries when you push the CLEAR key and don't get all zeros. Assembling the parts will apparently be a simple operation. This should be the first application of C/MOS for a consumer product.—*J. R. Free*

Look and Listen

[*Continued*]

kind of program material, *including* CBS four-channel discs. An integrated-circuit chip will soon be available to manufacturers so they can build the new circuit into their equipment.

Hard to predict the impact of this announcement, but it just may end the compatibility squabble for good.

On the record

I recently received six cassettes from the Musical Heritage Society, and they are a pleasure to listen to. Good sound, well recorded on premium TDK SD tape. Performances by various European soloists, conductors, and orchestras. All Dolbyized except the Beethoven, and it makes a big difference.

The recordings I heard: Beethoven's Symphonies 8 and 9 (MHC 2020, 2021); Haydn's Symphonies 103 and 104 (MHC 2140); four Vivaldi Concerti (MHC 2036); an album of lute and guitar music (MHC 2023); and a cassette called "History of Spanish Music in Sound" (MHC 2024), a collection of lovely and unusual vocal and instrumental songs.

Other cassettes this month—

● JANACEK: *Sinfonietta, Taras Bulba.* Bavarian Radio Symphony, Rafael Kubelik, cond. DGG 3300 104.

Spirited performance, fine sound.

● RESPIGHI: *The Fountains of Rome. The Pines of Rome.* Philadelphia Orchestra, Eugene Ormandy, cond. Columbia MT 30829 (Dolbyized).

Columbia is now releasing all cassettes in Dolbyized form, and it is a welcome change. Sympathetic readings by Ormandy; recorded sound big and rich and right for these lush scores.

● HOLST: *The Planets.* London Philharmonic, Bernard Herrmann, cond. London/Ampex M94049.

Lots of pyrotechnics to show off your rig in this flashy, dramatic score.

● *Mantovani in Concert.* London/Ampex M57174 (Dolbyized).

Vintage lush Mantovani sound; splendid, clean recording.

And an assortment of new discs, reviewed by Arthur Fisher—

● J. STRAUSS: *Waltzes, Polkas, Marches.* Berlin Philharmonic, Herbert von Karajan, cond. DGG 2530 027.

A virtuoso conductor and orchestra radiating so much Viennese *gemütlichkeit* you'll have to mop the whipped cream out of the grooves. Solid sound.

● SCRIABIN: *Poem of Ecstasy*; TCHAIKOVSKY: *Romeo and Juliet.* Boston Symphony, Claudio Abbado, cond. DGG 2530 137.

Soul music—Russian soul, that is, and not everyone's cup of *tchai.* Stunning sound, impassioned performances.

● G. P. TELEMANN, G. TORELLI, L. MOZART, F. J. HAYDN: *Trumpet Concerti.* Pierre Thibaud, trumpet; Bamberg Symphony, Otto Gerdes, cond. DGG 2530 138.

Beautiful music, and a new standard for trumpet recordings: Sonic and musical balance between orchestra and soloist is first-rate. Thibaud is spendid, but some may find his lush playing too Harry Jamesian in the baroque works. PS

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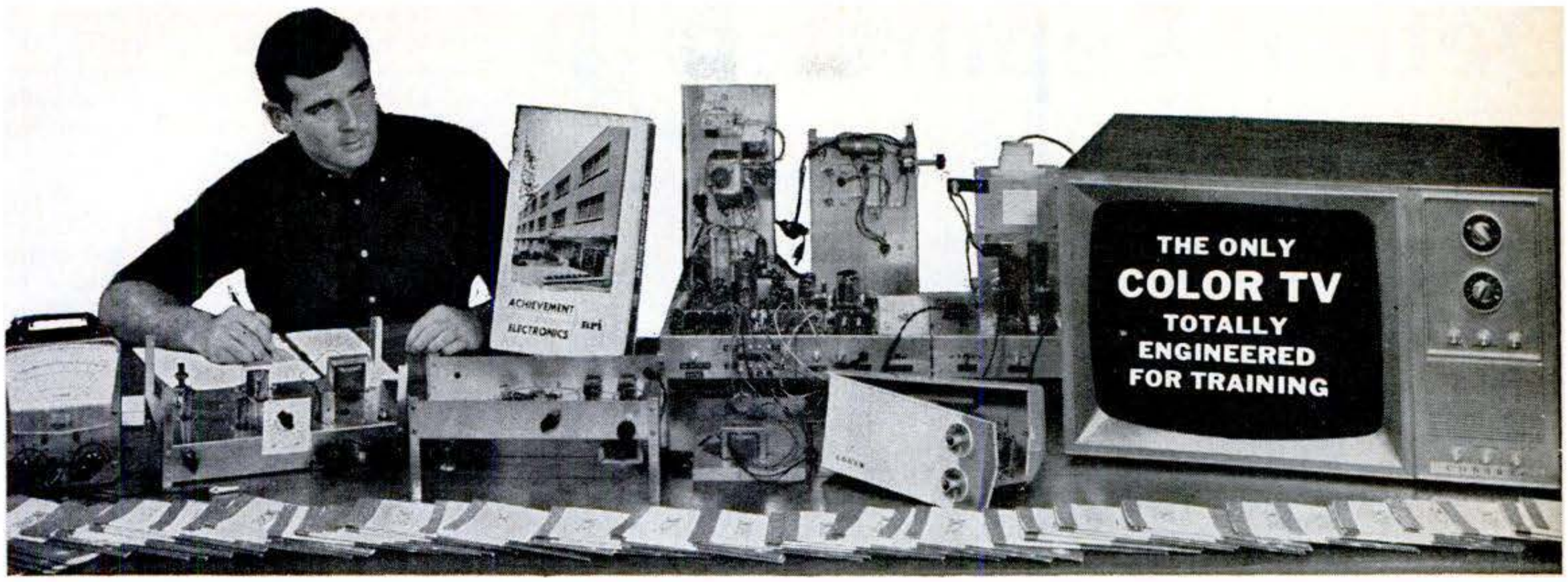

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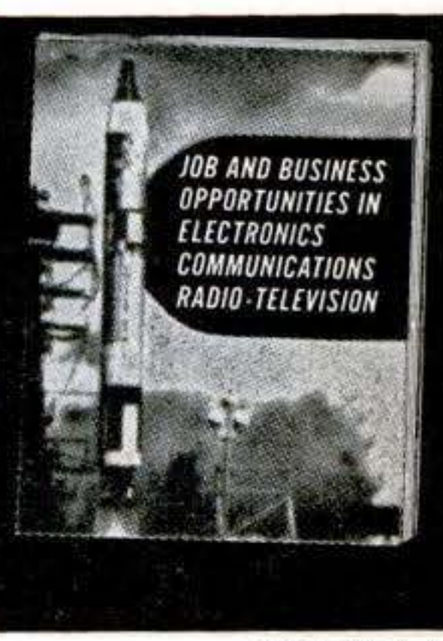

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Detroit Report...

By JIM DUNNE / *PS Detroit Editor*

How the air bags came through their latest tests

General Motors' Experimental Safety Vehicle uses a combination of air bags and heavy padding to protect passengers for the prescribed 50-mph barrier crashes. Even so, GM researchers claim that crash tests so far show that all passengers in the present ESV car would be killed if it hit a barrier at 50 mph. Some of the passengers, GM says, would only be "slightly killed" by the impact, indicating that with a little more development, the car could meet government survivability standards. If GM is successful in developing the ESV to its expected potential by late 1972, the ESV would have the capability of running into another car at upwards of 100 mph and still protect passengers from fatal injuries. GM will not say what would happen if the air bags were replaced with shoulder and lap belts, but indicated that the air bags were the only answer to forces developed at 50-mph barrier speeds. Five General Motors ESVs will be built at a cost to the company of over a million dollars.

And the Ford ESV

Ford has taken a completely different approach in developing its ESV, and is using a stock Ford LTD four-door sedan as the basic vehicle. Ford also differs from GM in that two restraint systems—air bags and belts—will be developed concurrently. This approach will tell which restraint system does a better job. In exterior appearance, the Ford ESV has a longer hood than its stock counterpart, but the rear deck is shorter. Both bumpers are supported by hydraulic struts attached to the frame, a system that protects the body from 10-mph impact damage. Like the GM design, the Ford ESV will hold five passengers and in its present configuration is well over the federal 4,200-pound curb-weight limit. Changes have been made in the brakes—including the addition of a two-wheel antiskid system—wheels, tires, and front and rear suspension to meet the handling and braking requirements of the Department of Transportation. Both Ford and GM are developing the cars at a cost to the government of $1.

Hone 'n Plate—a time-saver

A new development in metal plating may have far-reaching consequences in future automobiles. The Ex-Cell-O Corp. has announced that its Micromatic Hone Division can now hone and plate a metal in one operation in much less time than previously needed for plating alone. Called hone-forming, the process can be applied to almost any cylindrical shape, but has proven very effective in honing connecting-rod holes and plating with copper. The plating, done with an electrolyte solution, is confined to the honed surfaces exclusively. Many plating materials can be used, including chrome. The honing process both fills the pits and voids, and plates high points in rough surfaces. Engine experts are excited about the possibility of using hone-forming to plate Wankel engine cases—now one of the mass-production bottlenecks of the rotary engine.

More hatchbacks coming

Watch for hatchback styling, similar to that on the Vega and Pinto Runabout, on more new models. American Motors will bring out a hatchback Hornet in '73, a sporty model in AM's compact line. And, as reported earlier, Pontiac, Chevy, and Oldsmobile will market a hatchback version of the GM "X" body—Nova, Ventura II—sometime in the 1973 model year, too. These cars will eventually replace the sporty compacts completely in the GM and AM lineup. You can look for Chrysler and Ford to bring out similar models later. The hatchback, first seen on a PS cover [Feb. '70], has proven popular, and it is especially attractive to the auto makers because it's a low-cost alternative to the slow-selling sporty compacts.

Now—Project Amigo

American Motors has tentative plans to market a small, Wankel-powered car within five years if the industry swings to the rotary engine in a big way. The AM car—code name, Project Amigo—would use a General Motors Wankel and have front-wheel drive. There'd be different models, including a wagon, sporty coupe, and four-door sedan. The Amigo body design will take advantage of the features of the front-wheel drive train, and interiors will be as roomy as many larger cars. If the Amigo ever gets to market, it will replace AM's Gremlin. But the final go-ahead awaits the availability of GM's rotary engine, and this is seen as at least two years away. Right now the plan is so confidential that AM clams up at the mention of Amigo.

Those body cutbacks

Supplier companies that sell to GM are taking a severe financial beating while the auto company lengthens the life span of car bodies, cuts back on the practice of ordering new body and chassis parts every few years. But the silver lining is peeking through. GM is telling its surviving suppliers to hang on for a few more months; that it has a big program scheduled for later in 1972 that will mean a new body style for all of its car divisions. This is the rumored 10-year body that GM is said to be proposing for its Wankel-powered cars, a design that will be used on Chevys, Pontiacs, Olds, Buicks, and Cadillacs. The catch is that with the 10-year cycle in the offing, suppliers will find even more lean years in the future.

Fords to wear Ford tires?

Ford Motor quietly began questioning dealers on the idea of marketing a new tire under the Ford brand that will replace rubber-company names on tire sidewalls. This does not mean that Ford is going into the tire manufacturing business. The company tried that once, and it cost a bundle. Before WWII Ford had some rubber plantations in South America and built its own tires under its own name. But the operation was inefficient and the project was abandoned during the war. Ford now wants to find out if its dealers have any strong objection to the use of the Ford name on tires on future Ford cars. Under the proposed plan, Ford would continue to buy its tires from present suppliers like Goodyear, Firestone, and Michelin, but have the Ford name prominently displayed on the sidewall.

New word on unleaded gas

The use of unleaded gas in your car does more than simply clean up the exhaust. It also cleans up the engine oil, cleans it up to a degree that makes possible a longer recommended interval between oil changes. A GM study shows what oil experts have known for many years: Leaded gasoline contaminates engine oil. With the change to exclusively lead-free gasoline, and the use of new high-quality (SE) oils, engine rusting and corrosive wear will be almost eliminated and low temperature sludging will be reduced. Whether these new oils can perform for longer intervals remains to be seen, but all signs point to an extension of the period of time between necessary oil changes if you use lead-free gasoline.

Plastic car is growing

The use of metal parts in automobiles has been shrinking in weight and number for the last 10 years, and the ingenuity of plastics manufacturers continues to cut into areas where steel and iron have been traditionally used. Latest switch to plastic is the intake manifold on the 1972 Porsche. Made of an injection molded plastic, the manifold is lighter, has smoother bores, and costs less than the metal part it replaced. The significant feature of this plastic application is its use in an area of high temperatures. Attached directly to the engine, what this means to the buyer is lighter weight, less expensive replacement costs, and better distribution of the air/fuel mixture from the carburetor to the combustion chamber. Look for other manufacturers to take a close look at the Porsche plastic manifold for use in their own cars. PS

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Decide for yourself.

The old amp/hours method of rating batteries was actually based on measuring a battery's ability to light a lightbulb over a long period of time.

The new Delco watts rating is a measure of the cranking power (in watts) available in a Delco Energizer at zero degrees.

The old way seems fine, if you plan on driving a lightbulb. But for those of us who get around in a more normal fashion, the watts rating is an ideal battery rating system.

Your car's engine needs a particular amount of starting power, depending on its size and how many accessories are attached to it. The Delco watts rating makes selecting the right battery easy and exact. Because the watts rating is molded right in the case of most Delco Energizers. If your car's engine needs 3600 watts of starting power at zero degrees, for instance, there's a Delco Energizer available for you rated exactly that way. Just ask your nearest Delco dealer for the Delco Energizer that's right for your car.

Unless, of course, you drive a lightbulb.

AMPERE HOURS vs. WATTS: WHAT'S THE BEST WAY TO BUY A BATTERY?

Note to GM car owners. Your new vehicle came with a Delco Energizer rated in watts. When you have to replace it, the new battery should have at least the same number of watts as the original.

The more you know, the more you'll want Delco.

GM
MARK OF EXCELLENCE

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Recreation Roundup

. . . on the go with PS

By HERBERT SHULDINER

Pickup for campers picks up new refinements and muscle

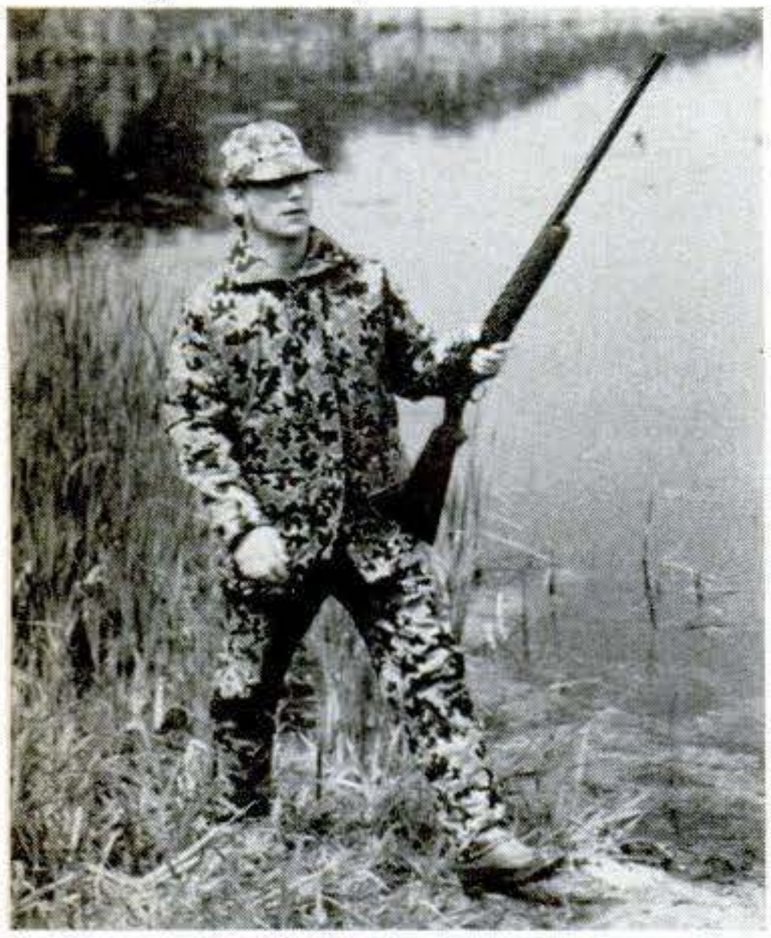
Not long ago, experts were consigning pickup campers to the fate of dinosaurs. Now Detroit is embarked on a program to turn pickups into safer and more convenient vehicles for toting campers around. This new Dodge, for instance, has a tailgate that is removable without tools. It also has optional pickup packages capable of carrying loads of up to 4,645 pounds. You can expect more pickup camper improvements in 1973.

Camping and the peaceful life

One day last fall I drove a Winnebago Brave motor home into a private campground located in New York's Catskill Mountains to enjoy an Indian Summer weekend outdoors. No sooner had I parked my rig and hooked up than the quiet air was punctured by a growling trail-bike engine. Turned out that most of the campers in the park were regulars—and most were at least two-bike families. Bikes kept zipping through the campground roads until a 7 p.m. curfew.

It seems to me that camping and trail-biking are not presently compatible. Both can be fun, but they really need separate locations. That's because trail-bike makers still have not produced machines with adequate mufflers. It's possible to make quieter trail bikes now and remove the annoyance to nonusers.

Hunting suit floats, too



This new camouflaged hunting suit has a double-duty foam lining—keeps you warm, and keeps you afloat if you fall out of a boat or wade out too far. It's made by Stearns Mfg. Co., St. Paul, Minn., costs about $90.

Camper instructions hard to find

When your camper isn't working the way it should, where can you turn? With few exceptions, nowhere—your own ingenuity has to supply the answers.

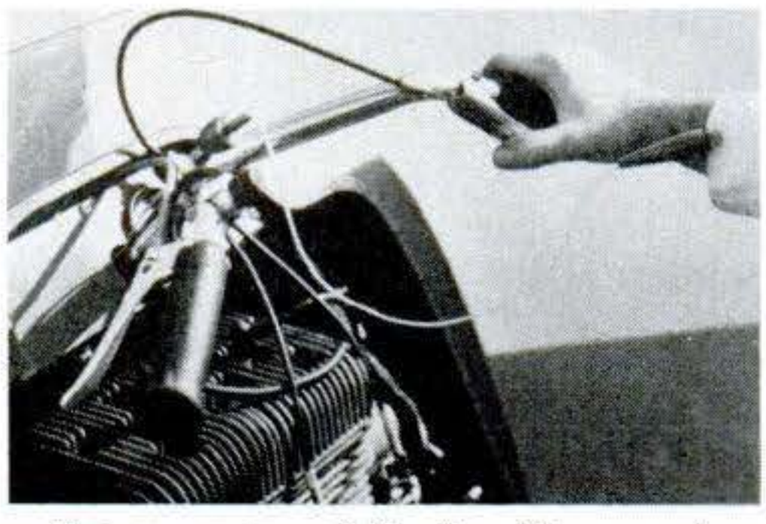
This is the consensus of a group of PS editors who have been testing campers for the past year. We have found that few camping vehicles come with a useful manual that explains how the rig should be set up and how to troubleshoot problems yourself.

Most of the campers we encountered arrived with a scattering of envelopes containing instructions for stoves, toilets, heaters, air conditioners, and other equipment. Surprisingly, the instructions were mainly for the benefit of camper manufacturers, not the eventual buyer. They are designed to help the manufacturer install the appliances, but are usually vague about how to use and enjoy the gadget.

Where apt instructions with drawings could make lighting a heater simple, the usual folder turns the job into a minor ordeal. The same holds true for other appliances. Right now, verbal instructions from the dealer at the time of delivery are all you have to go on.

If you've had better luck with your camper manuals, let us know about it so that we can give the manufacturer a well-deserved pat on the back.

Tether stops runaway snowmobiles



Frozen snowmobile throttles are less dangerous with this new safety tether switch. Made by the Kalamazoo, Mich., Engineer Co., one end clips to your suit. If you're thrown off your machine, it yanks a switch to cut the ignition.

Winter towing precautions

Last winter, I joined the growing army of outdoorsmen who tow RVs behind cars and pickups over icy roads in search of cold-weather fun. Piloting an International Travelall (photo above), I discovered some problems you won't encounter during warm weather. So I went to R. C. Bakkom, International's manager of light-truck sales, for advice.

Bakkom recommends that a towing vehicle be equipped with snow tires on all four wheels—with studs where legal. Use trailers equipped with brakes to reduce the risk of jackknifing, he says.

But the main thing to watch out for, Bakkom says, is to be sure your trailer is hitched up level. A frame hitch is best. Actually weigh your trailer before you hitch up. Then see that no more than 15 percent of the load rests on the hitch. It's also potentially dangerous to have much *less* than 15 percent resting on the hitch. An ordinary bathroom scale can be used to check tongue weight.

It's always a good idea to take precautions when towing trailers, but winter ice and snow exaggerate the usual hazards. These few simple precautions can help you get there safely. PS

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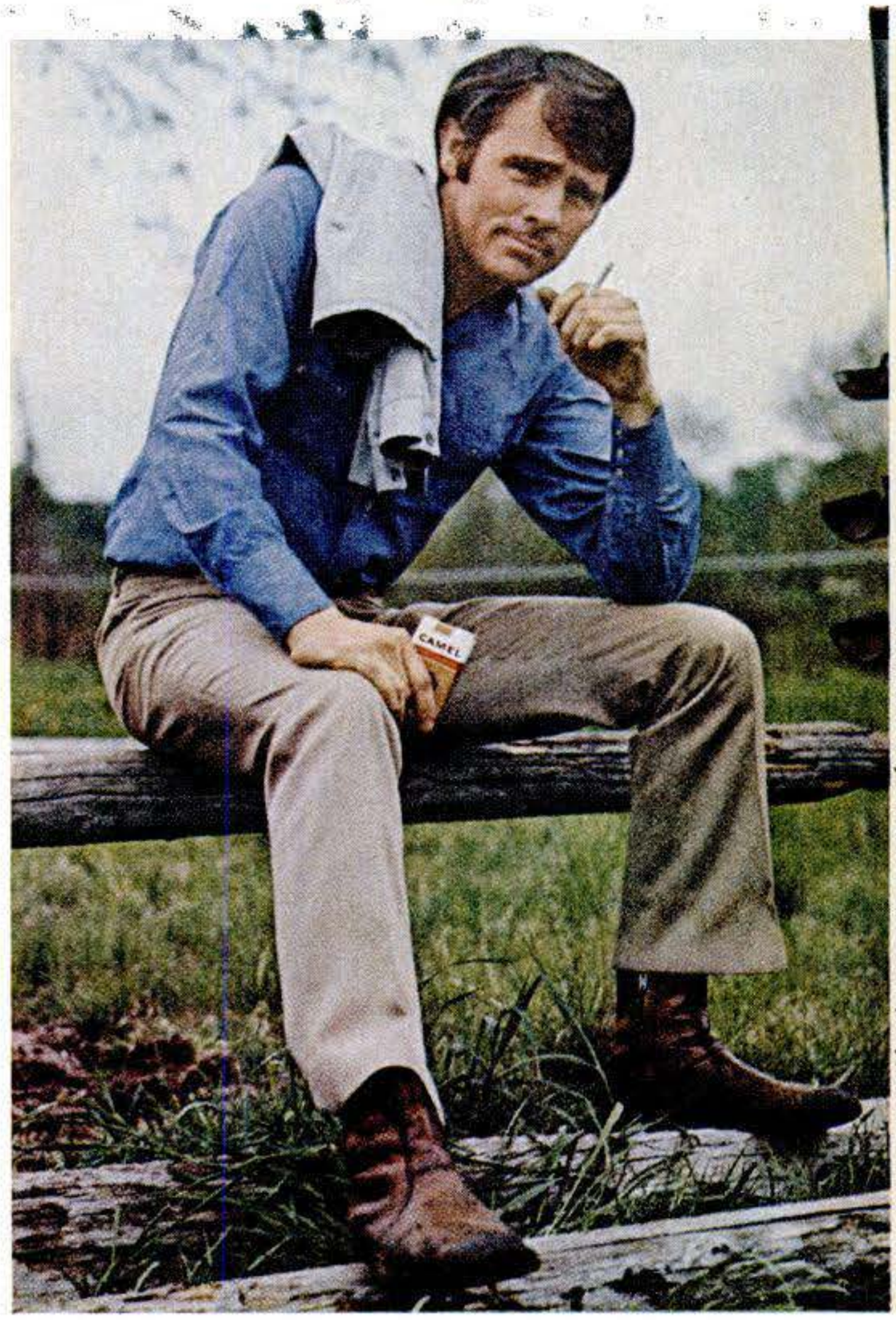
On his last hunt, Major Hocum smoked a cigarette stamped with his family crest.

Now everybody will be smoking cigarettes stamped with their own family crest

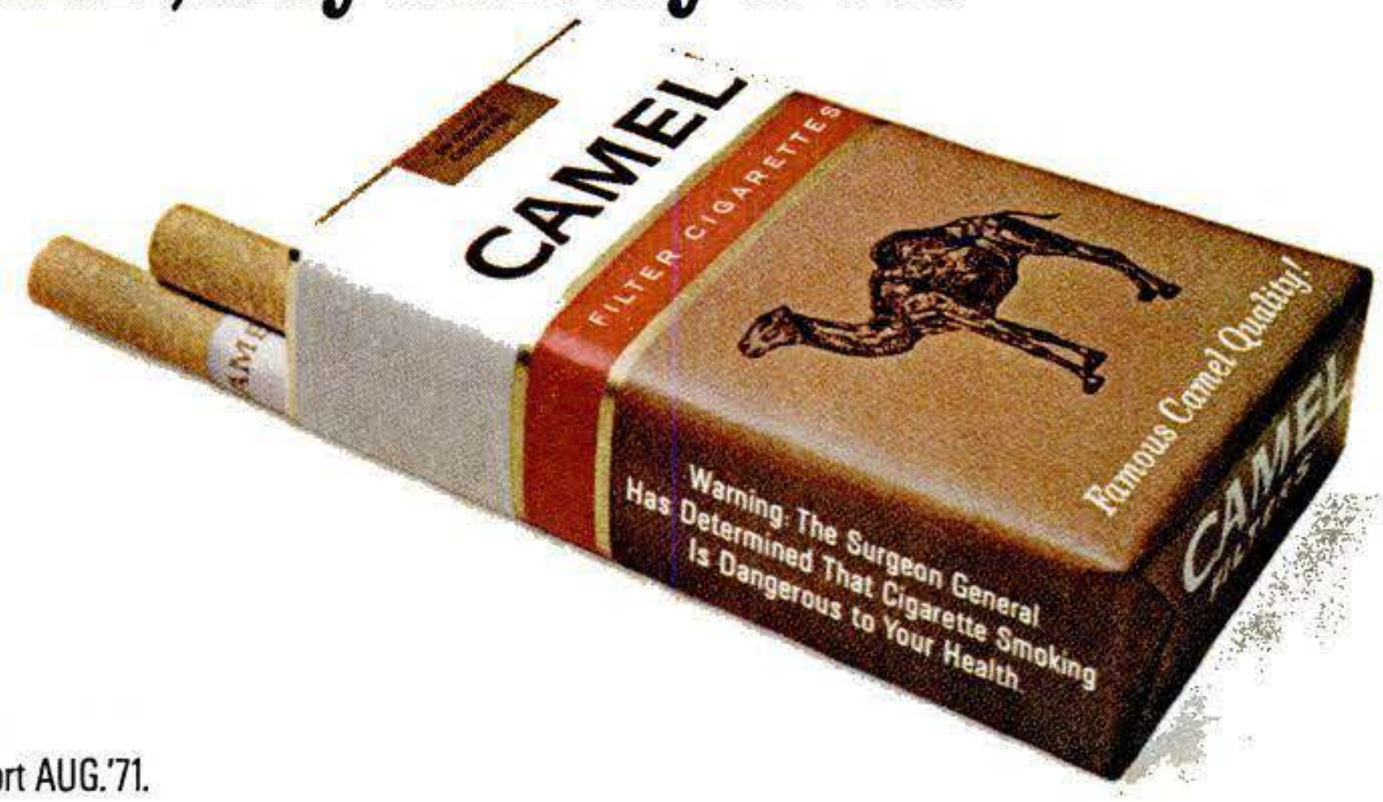
...almost everybody.



©1971 R. J. Reynolds Tobacco Company, Winston-Salem, N.C.

Camel Filters. They're not for everybody.

(But then, they don't try to be.)



20 mg. "tar," 1.3 mg. nicotine av. per cigarette, FTC Report AUG.'71.

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The age of the Colt
Pick up one of these new Colt hunting knives. You're right out by the campfire, surrounded by the warmth of a quiet night. And you're eager about tomorrow's hunt. There's something uniquely American about having a good knife at your side.
Maybe it goes back to Jim Bowie. Or maybe it's just the pride of owning a professionally crafted work of art. Treat yourself to one of these new knives with famous Colt quality. At your Colt's Registered Dealer.

The age of the Colt

THE NEW WILDERNESS LINE
Each knife is hand forged and hand polished in England from matchless Sheffield high-carbon steel. Each is honed to a smooth, ultra-sharp edge. A one-piece tang passes completely through the resin-impregnated, laminated wood handles, making them virtually indestructible. The line includes four Sheffield steel sheath knives and one stainless folding knife. Each has its own individuality. Heavy duty leather scabbards are included.
The Trailblazer. Sturdy general purpose camping knife with 7" blade. Hefty enough for cutting kindling and for use as a light cleaver. Handle has end cap with thong holder. $54.50
The Mountaineer. Bish-designed general purpose knife with 6" blade. Brass guard and end cap. Can handle a wide variety of chores. $47.50
The Plainsman. General purpose knife with 5½" blade. Nickel handle cap with thong holder. Can be put to many different uses in camp or on the trail. $39.95
The Trapper. Curved point, 3½" blade designed especially for skinning. Brass guard and end cap with thong holder. $29.95
The Tuckaway Hunter. Compact, handy folding knife with heavy duty 3½" stainless steel blade. For the hunter who prefers less bulk or likes to pack one along as a standby. Heavy duty carrying case with snap fastener. $29.95
THE NEW SPORTSMAN LINE
Sturdy, high quality line made from select high-carbon steel. Precision formed, machine ground and polished. Rosewood handles are laminated and resin-impregnated with guards and pommels of polished brass. Each knife comes with heavy leather scabbard, formed and stitched. All-purpose knife with 4½" blade, $21.95. All-purpose knife with 5½" blade, $27.50. Trout and Bird knife with 4" blade, $19.95.
Both new lines of Colt knives are available at your Colt's Registered Dealer. Stop in and take a look.

Colt Industries Colt's Small Arms Division
Hartford, Conn. 06102

Pointed jaws slip into an opening between smashed roof and car body. A turn of the control rings opens the jaws, and less than a minute later the roof is torn loose and raised almost three feet. Jaws can open or close completely in about 55 seconds.

Instant "Can Opener" for Crashed Cars

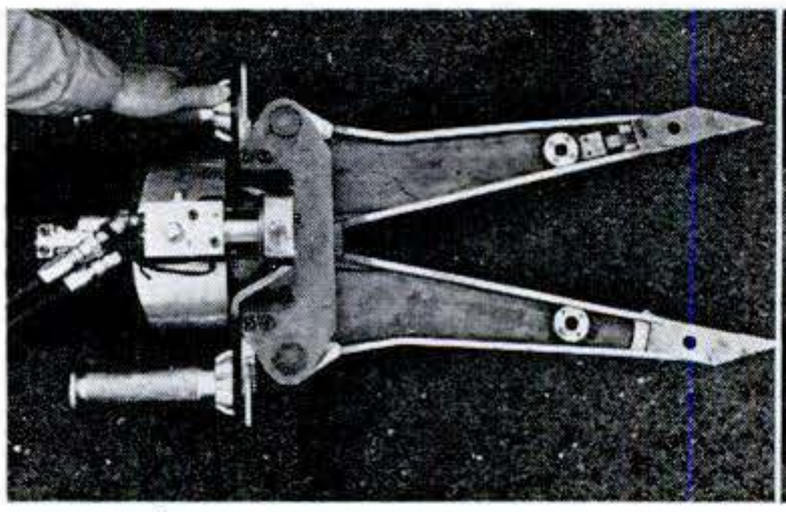
At a stock-car race 10 years ago George Hurst watched as rescuers worked frantically over a badly battered wreck, trying to free the injured driver trapped inside. More than an hour passed before the driver was freed and into an ambulance.

Next day Hurst was at work, pondering the design of a revolutionary tool for rescue work. Neither cutting torches nor abrasive cutting wheels—two standard tools in rescue work—would do. They're slow, and their sparks present a hazard near gasoline-soaked wrecks. Hurst's final design—10 years in coming—is a giant hydraulic claw that can literally rip a smashed car open in seconds. Here are the facts:

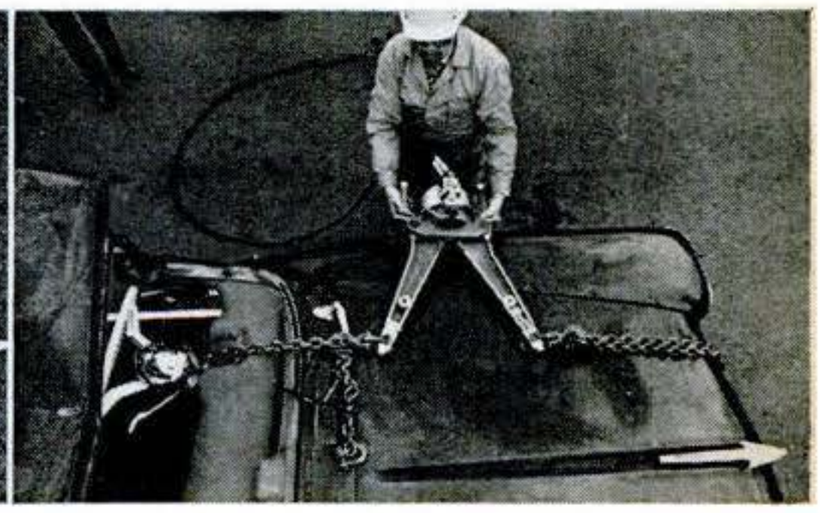
- It puts six tons of lifting, spreading, or pulling pressure in the hands of a single operator.
- Extensive use of aluminum and titanium make it light and easy to operate in any position.
- It can right an overturned car, open and remove jammed doors, raise a smashed roof.
- Replaceable snap-on jaws adapt it for spreading, crushing, slitting, piercing, and shearing.
- It's completely portable, fits easily in a truck or car trunk.

Rescue tool is fed by small 5,000-psi hydraulic pump. Pump can be set some distance from wreck. The tool is silent, an advantage in use near shock-prone victims.

The Hurst Rescue Tool is designed primarily for use by ambulance, fire, police, race-track, and other such rescue teams, but Hurst believes it has potential for quick rescue work in aviation, construction, and mining situations, too. Price should be around $3,500, within the reach of many rescue squads. Hurst Performance, 50 West Street Rd., Warminster, Pa., makes it.—*A. J. Hand*



Fluted control rings on handles let operator control jaws with either hand. Here tool is fitted with piercing/spreading jaws.



Special chain attachment lets a rescuer pull up on a smashed steering column, freeing a victim who is pinned in his seat.

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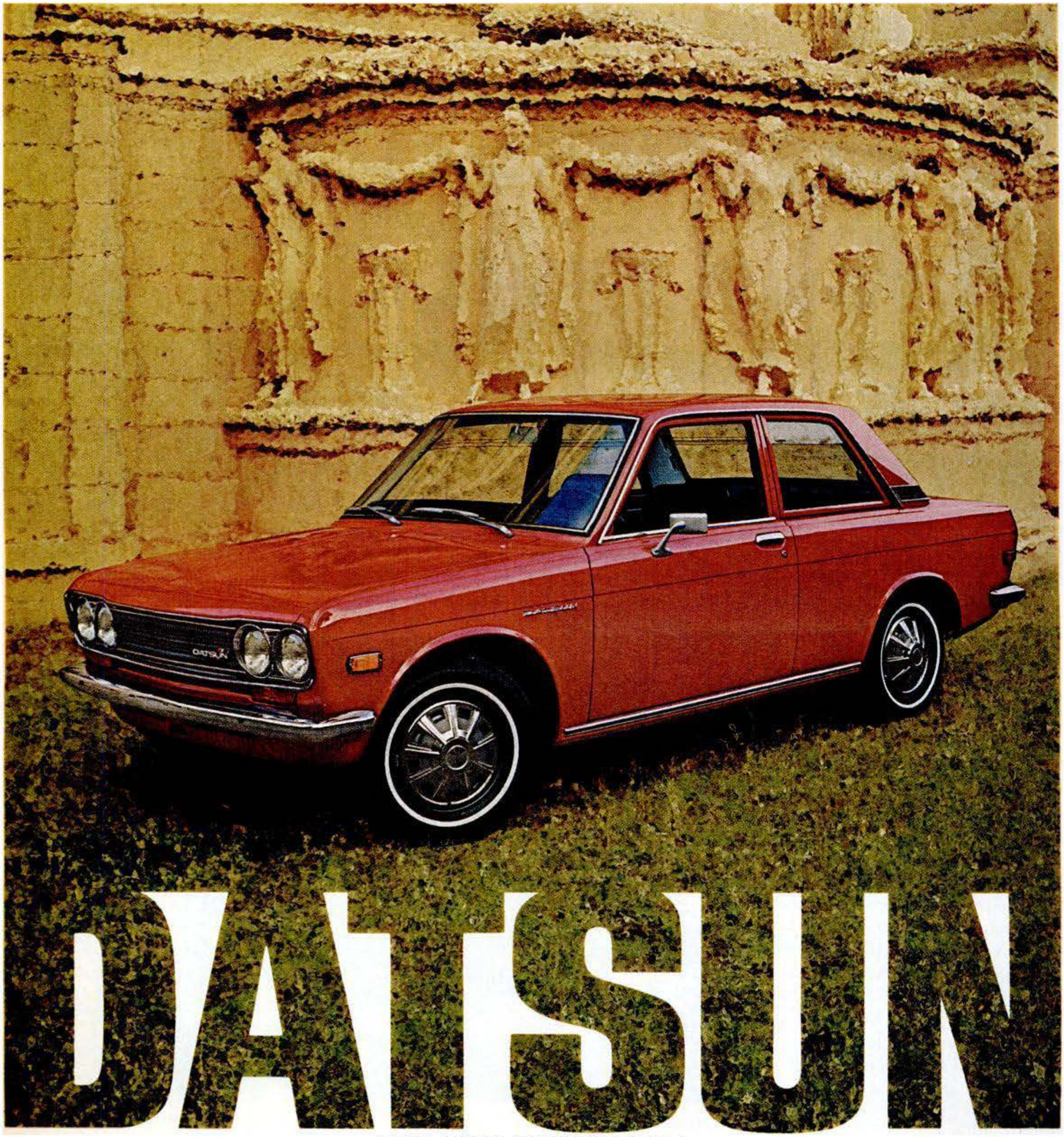
Under our sedan body lurks a secret sports car.

At first glance, you might mistake the Datsun 510 2-Door Sedan for just another economy car.

But under that civilized exterior lies some pretty exotic machinery:

Independent rear suspension. Front disc brakes. An overhead cam engine. A slick 4-speed transmission. That's the stuff sports cars are made of, as our competitors in the high-pressure 2-5 Trans-Am racing series have discovered.

Drive a Datsun...then decide.



FROM NISSAN WITH PRIDE

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Popular Science
REG. U.S. PAT. OFF. MONTHLY

PS: What's News...

Keeping You Posted from Behind the Scenes

With this issue, POPULAR SCIENCE enters the year of its 100th Anniversary. You will find only five other major magazines *(Harper's, The Atlantic, Harper's Bazaar, Scientific American,* and *National Police Gazette)* on the newsstands today that match this record of a century of continuous publication under the same name. The first issue of *The Popular Science Monthly* appeared in May 1872. We're going to bring you a special Anniversary issue in May 1972 to commemorate that event. I'll be telling you more about it in the coming months, but judging from the work now in progress, the May issue is apt to become a collector's item.

As a reader of POPULAR SCIENCE you enjoy a unique advantage over your neighbor who relies on the general news media for word about the world we live in. Though you'd never guess it from reading the papers and watching TV, what's happening in science and technology has a more profound effect on the way we live than all the politics, personalities, protests and hand-wringing about pollution that fills the front-page headlines. For example . . .

The Wankel grows up

When we published the first story on the Wankel engine in March 1960, we got a lot of ribbing from some of the top engineers in Detroit for considering this "screwball" invention newsworthy. We have, however, backed up our initial judgment of its importance with more than a dozen feature stories following up developments of the rotary combustion engine. You have watched it grow from a laboratory curiosity to one of the top contenders among designs that will help to solve our automobile-engine pollution problems. On page 83 you can read the latest chapter in this continuing story. Our 10,000-mile test drive of the Mazda RX2 tells a story of fully-matured engineering on a Wankel-powered car that has made an enviable record for low emissions.

Incidentally, Dr. Felix Wankel is still inventing. See Jan Norbye's column on p. 12.

Taking 250 pictures on one negative

The unbelievable headline above appeared on a story in PS, February 1966. Our reporter actually witnessed a breadboarded demonstration of this astonishing feat. I'm sorry I can't report a success story on this one. Recently we checked with Aeroflex Laboratories, Plainview, N. Y.: "We licked all the technical problems," an Aeroflex executive told us. "But in doing that we priced ourselves out of the market. It was one of those cases where the operation was a success, but the patient died." Maybe some of you photographers will pick up the threads of this research and find a way to beat the money problem. Stranger things have happened.

It cools without refrigerant

Recently our Midwest Editor, Al Lindsley, got a call from Dr. Tom Edwards, the man who invented the Roto-Cooler reported by Al in the December 1970 issue. This is the machine that cools air with only one moving part and no circulating refrigerant except air. Dr. Edwards says he has now incorporated under the name U.S. Rovac and has some 30 firms dickering for his invention. This is another invention some knowledgeable engineers have laughed at us for publishing, but I think you'll be hearing a lot more about it in the next few years. I'll keep you posted.

Our mountain of junk

We've run a couple of stories in recent months about what scientists are doing to help us cope with the mounting problem of garbage disposal [PS, April '71, November '71]. There is hopeful progress. I've just seen a report that Ecology, Inc. of Brooklyn is processing some 100 tons of New York City garbage a day and producing 50 tons of compost that sells, after adding some nutrients, for $500 a ton. That makes garbage sound like a valuable natural resource rather than a troublesome discard, no matter how you keep books.

New rotary heat exchanger

Unless you're an engineer, you may think a new heat exchanger means nothing to you. You'd be wrong, though. If you missed the story in our March '71 issue, you may want to go back and read it. A dramatically more effective and efficient heat exchanger is the key element holding up the development of a practical external combustion power plant for cars. And among hundreds of other potentials it might eliminate thermal pollution of our rivers by nuclear power plants. I have word from a spokesman for the Donbar Development Corporation, which holds the patent rights on the new rotary heat exchanger, that they have signed licensing agreements with a number of major companies since our story appeared. Among these are Modine Manufacturing Company, the largest independent manufacturer of auto radiators in North America, and Caterpillar Tractor Company.

Ford's stratified-charge engine

Now they call it "PROCO," short for Programmed Combustion, but it's the same engine we told you about in July, 1968. It made headlines recently when President Nixon mentioned it in a speech and EPA later issued an announcement from Washington giving the impression that the engine met 1976 emission standards. It did, indeed, meet emission standards on a limited-duration test, but what many people overlook is that the standards also require passing a 50,000-mile durability test. A Ford spokesman has been quoted: "We need two engineers and three technicians just to keep it going from day to day." That sounds as though it's a long way from achieving the kind of reliability the average car owner demands. Research continues. I'll keep you posted on this, too.

Hubert P. Luckett
Editor-in-Chief

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THE STEAM STORY: PART ONE

Now—"Steam" Power in One

This external-combustion engine combines all systems in a single unit

By E. F. LINDSLEY/*PS Midwest Editor*

The first external combustion engine package — burner, boiler, expander, and condenser, all together—has just been patented by E. I. du Pont de Nemours and Company.

It has become increasingly apparent that such an all-systems-together package is essential if external combustion power is ever to match the neat, single-unit prime mover we're used to in internal combustion engines. Until now, however, the usual pattern has been burner, boiler, expander, and condenser strung together like Christmas-tree lights. With the Du Pont engine, plumbing troubles, sealing, pressure losses, and valving, plus high auxiliary condenser cooling loads are wiped out.

We visited Dr. Max Bechtold and Dr. William Doerner, developers of the engine, at the Du Pont lab in Wilmington, Del., and were impressed by their enthusiasm and solid assurance that they've produced a workable, practical engine, not a laboratory toy. At the same time, they both emphasized that the existing 20-horsepower model *was* a model and nothing more.

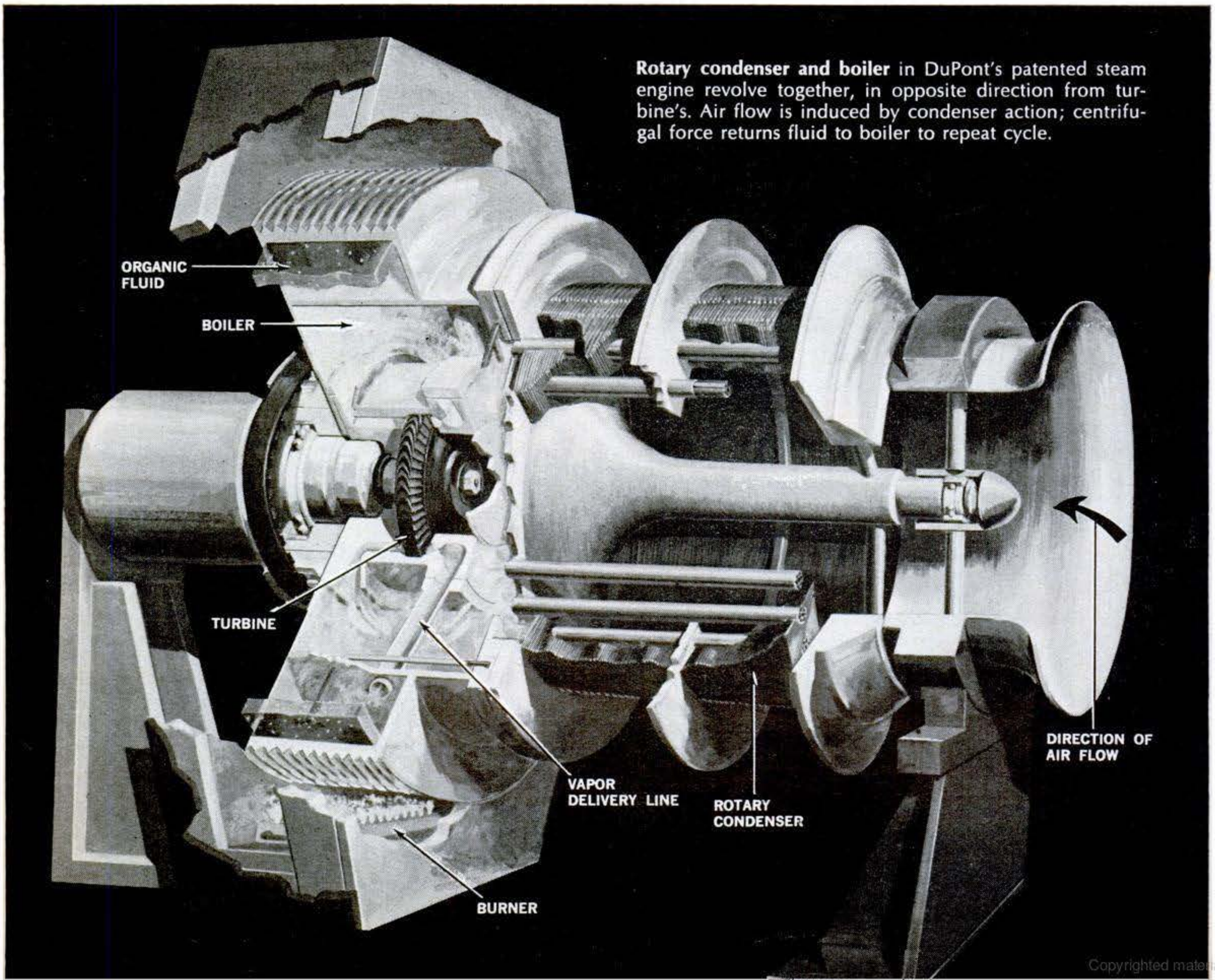
Du Pont won't make the engine, but hopes other firms will. Since the working fluid is organic (presumably of the Freon family), Du Pont believes that their greatest contribution from here on can be the improvement of the fluid.

Very hush-hush. Although Du Pont did not specify the exact working fluid, obviously they knew what they were about, both chemically and thermodynamically. Nor would they talk about the drive train from the engine to the load, or the precise means of throttling and load-response control. Since power output of the Du Pont engine comes from a turbine, which rotates at a modest (compared to a gas turbine) 10,000 to 12,000 rpm, there must be a provision to reduce the speed to practical mechanical input speeds.

Dr. Bechtold and Dr. Doerner envision some of the first applications on small generator plants, and they say they know how they will control speed accurately enough to keep electrical cycles within limits, and how they will pick up load when the switch is closed instantaneously. But just now, they aren't saying how.

What they are saying, however, is fascinating. Basically, the engine . . .

- Can operate without pollution on almost any suitable burner or fuel.
- Offers a quiet, lightweight, vibration-free, prime mover.



Rotary condenser and boiler in DuPont's patented steam engine revolve together, in opposite direction from turbine's. Air flow is induced by condenser action; centrifugal force returns fluid to boiler to repeat cycle.

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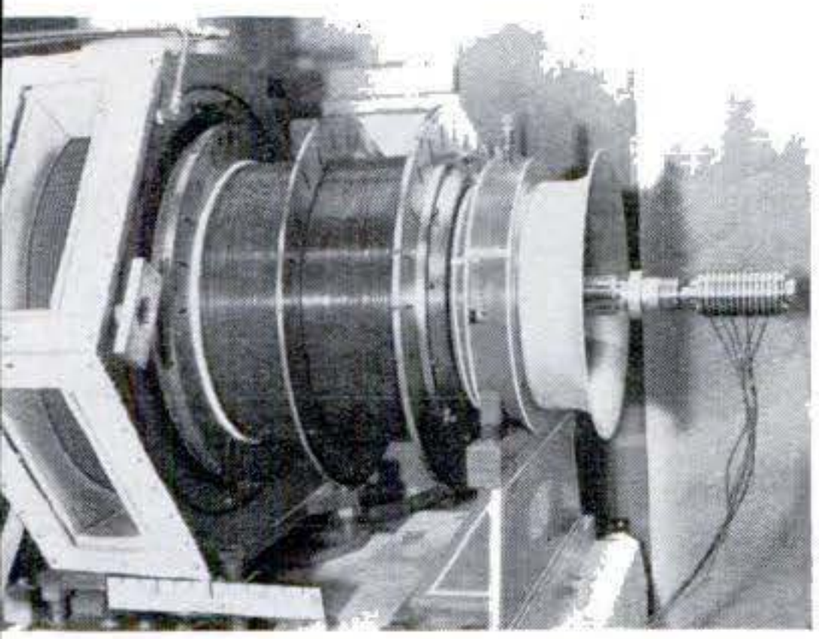
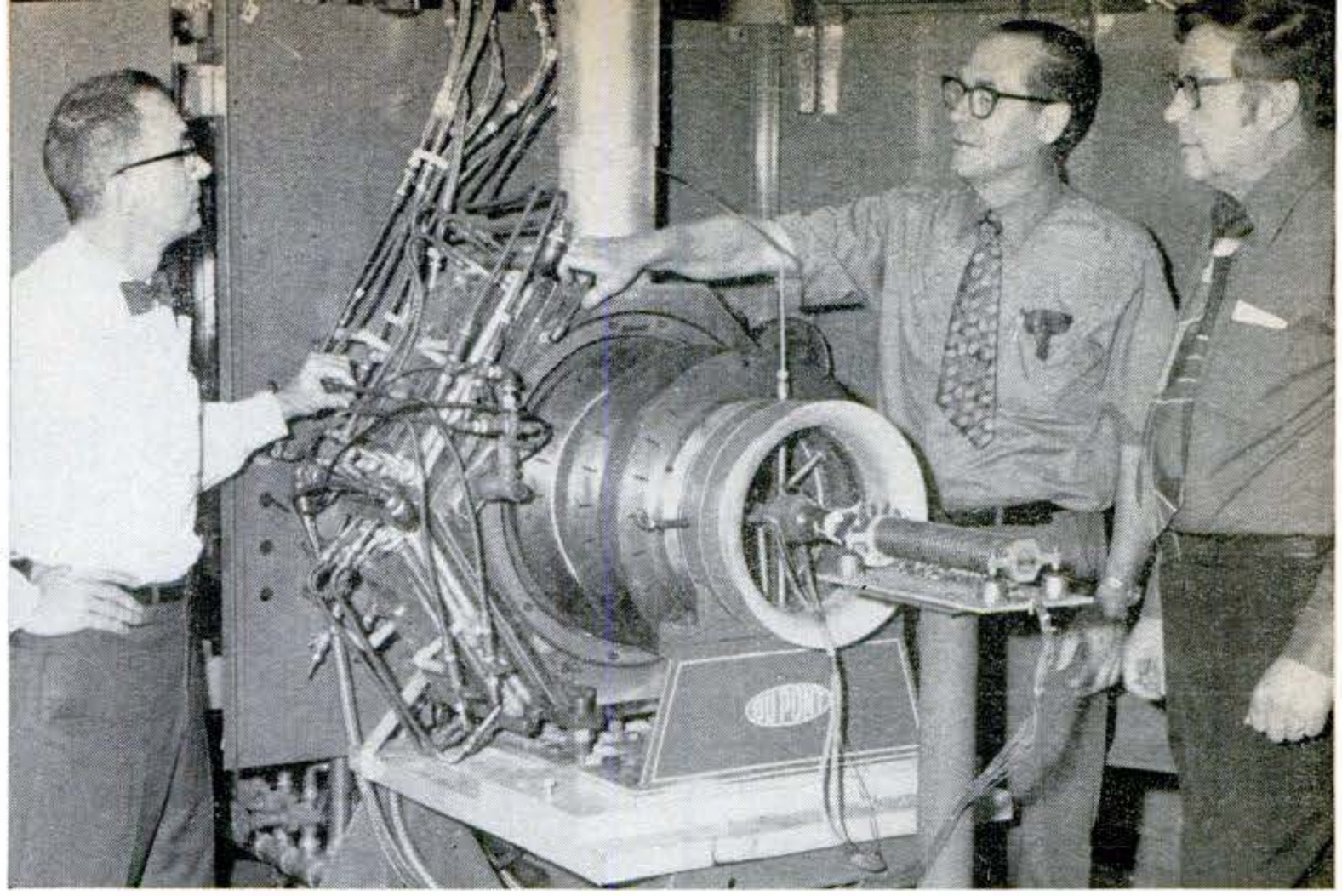
Package



Lab model shows mechanical simplicity, but the condenser is still heavily finned.



Dr. William Doerner (left) and Dr. Max Bechtold (right) explain lab engine to author. Use of glassblowing torches as heat source was merely for convenience.

- Needs no exotic, high-temperature-strength alloys in the turbine.
- Can be built at low cost.
- Has no valves, no dangerous high pressures, holds no boiler pressure at all if the engine stops turning, as in an accident.
- Has no condenser cooling fan.

Just the elimination of boiler feed pumps, piping, and valves is a major gain. To understand how this is done, look at the flow chart. Remember, you are looking at a Rankine cycle; the working fluid is used over and over.

How it works. The burner (A) can be any of many available within the state of the art. On the lab model, Bechtold and Doerner actually used readily available glassblower's burners; a trick that only a lab man would think of.

Whatever burner is used, the heat is transferred through the boiler wall to a very thin film of fluid (B) held against the inner wall of the drum-like boiler by centrifugal force. To start, an electric starter winds the engine up to operating speed. The boiler rotation is relatively slow.

Note that there is no "wickerwork" of tubes, nor anything really resembling a pressure vessel. Maximum boiler pressure is 150 pounds (absolute), and maximum boiler temperature is 650 degrees F. All other pressures and temperatures in the engine are lower, which explains why fancy gas-turbine metals are not needed.

The vaporized fluid leaves the boiler through tubes (C) terminating in the nozzle ring (D), and passes through the turbine (E). The turbine shaft drives the external load.

On the return to the boiler, the expended fluid enters the condenser tubes (F) and is cooled by the heavily finned condenser, which is rotating together with the boiler. Condensed liquid is pumped back through the tubes (G) not by an auxiliary pump, but by centrifugal action.

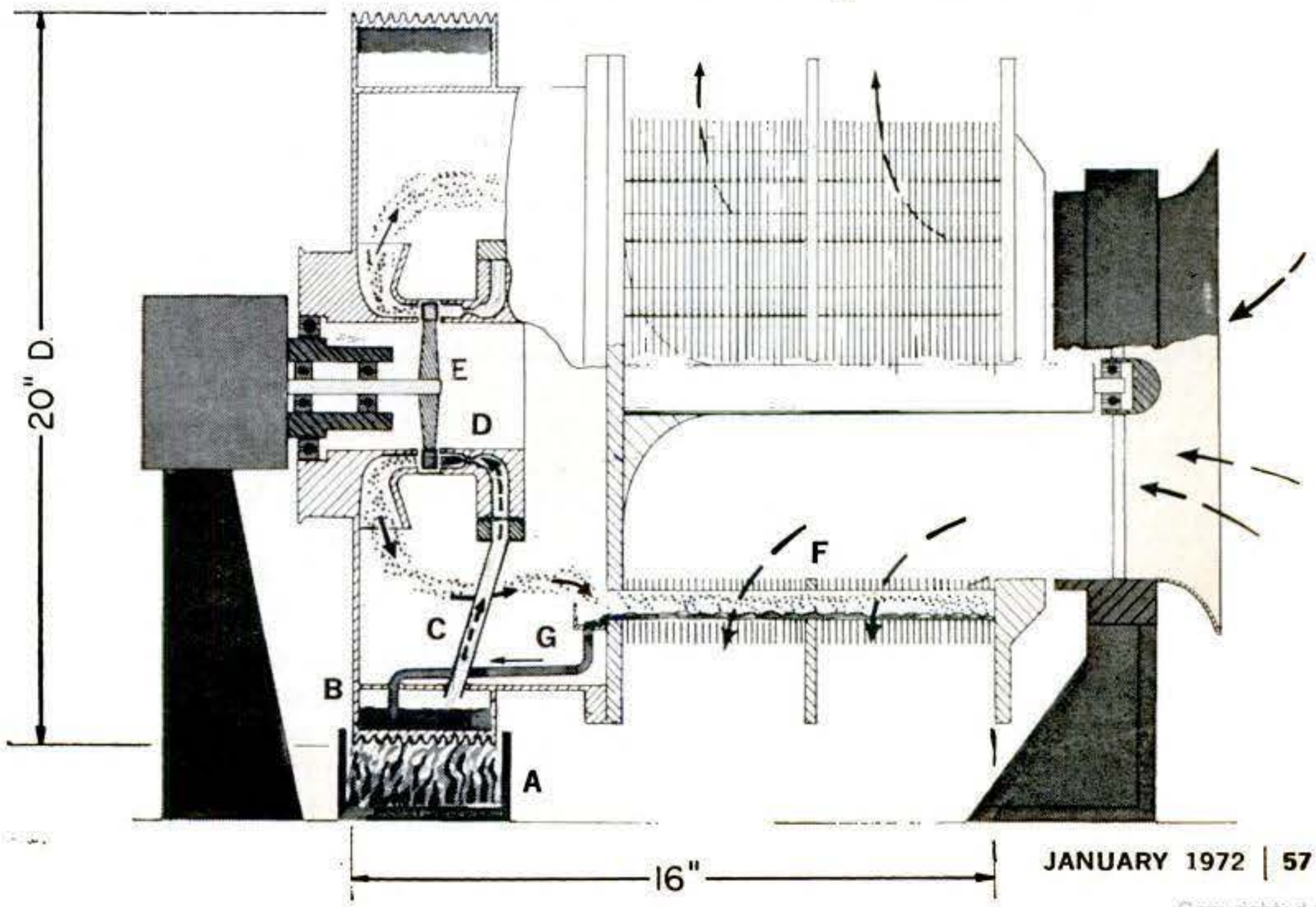
Thus, in the entire cycle, there are no valves, pumps, or transfers of fluid through seals or interfaces between moving and nonmoving components. Air flow for condenser heat exchange is induced by the rotating condenser without need for power-absorbing fans. This action, of course, does use some energy, but much less than conventional fans.

The pros and cons. There are great advantages in the self-contained Du Pont engine with all the vital parts rotating together. There may also be some disadvantages. At present, the physical practicalities of the rotating structure appear to limit the engine to a size capable of about 200 hp. Since the turbine does turn at fairly high speed, some form of transmission appears necessary although the turbine can be stalled, and the inherent torque ratio is 2:1, according to Bechtold and Doerner.

Still, this is not the same as a positive displacement engine, which does not really require a transmission. As in all EC engines, modulation of the burner is expected to control power output at least partially. An idling turbine in a stopped car, for example, would not demand the heat energy of full load. But to avoid time lag and provide instant response to load and operator demands, additional controls will surely be needed.

Summing it up, Dr. Bechtold and Dr. Doerner at Du Pont have made a tremendous jump in developing a self-contained external combustion package that solves many of the problems that have plagued EC progress. PS

For flow pattern of working fluid to boiler-turbine-condenser—and return—follow solid arrows below. Dotted arrows represent air flow through the condenser.



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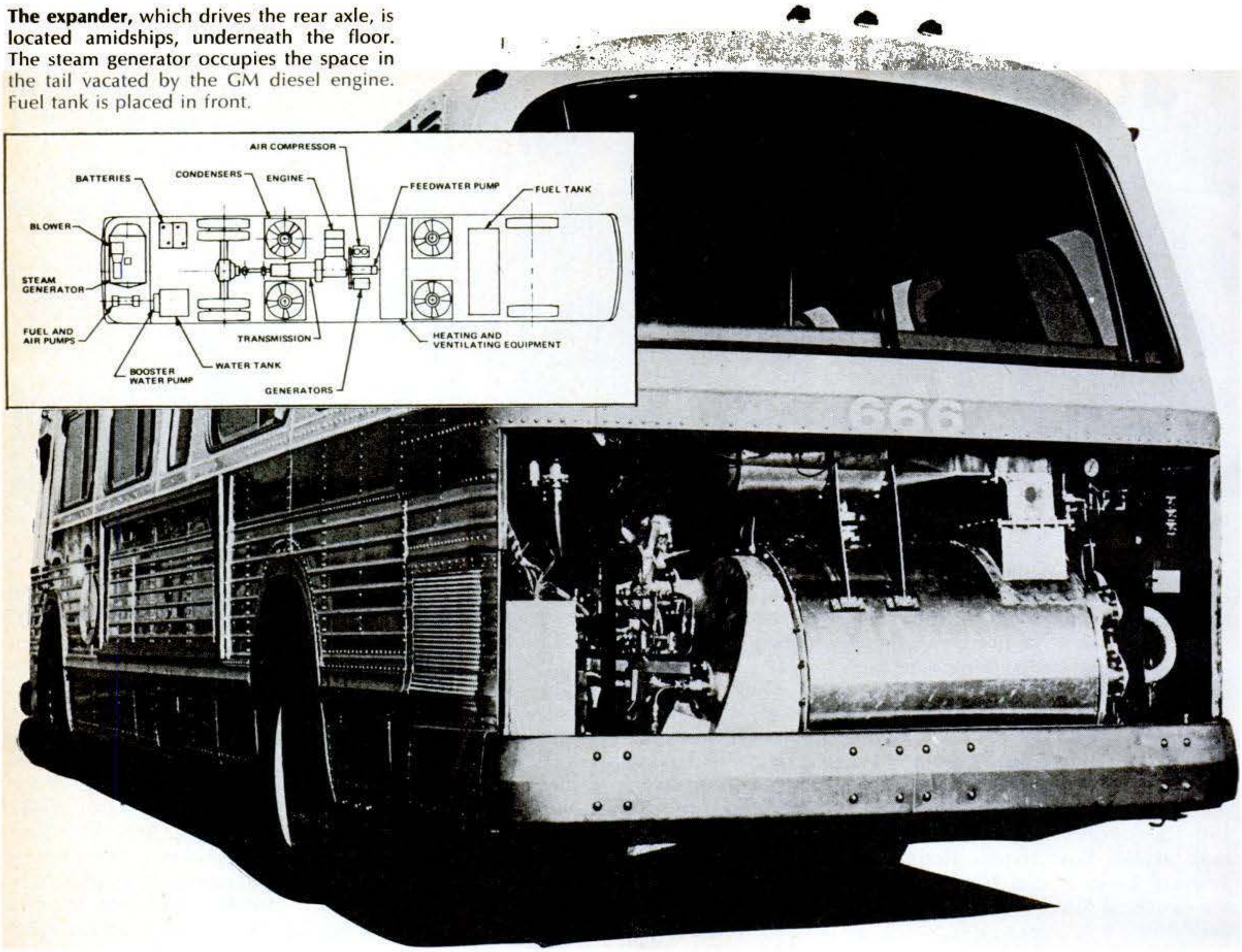
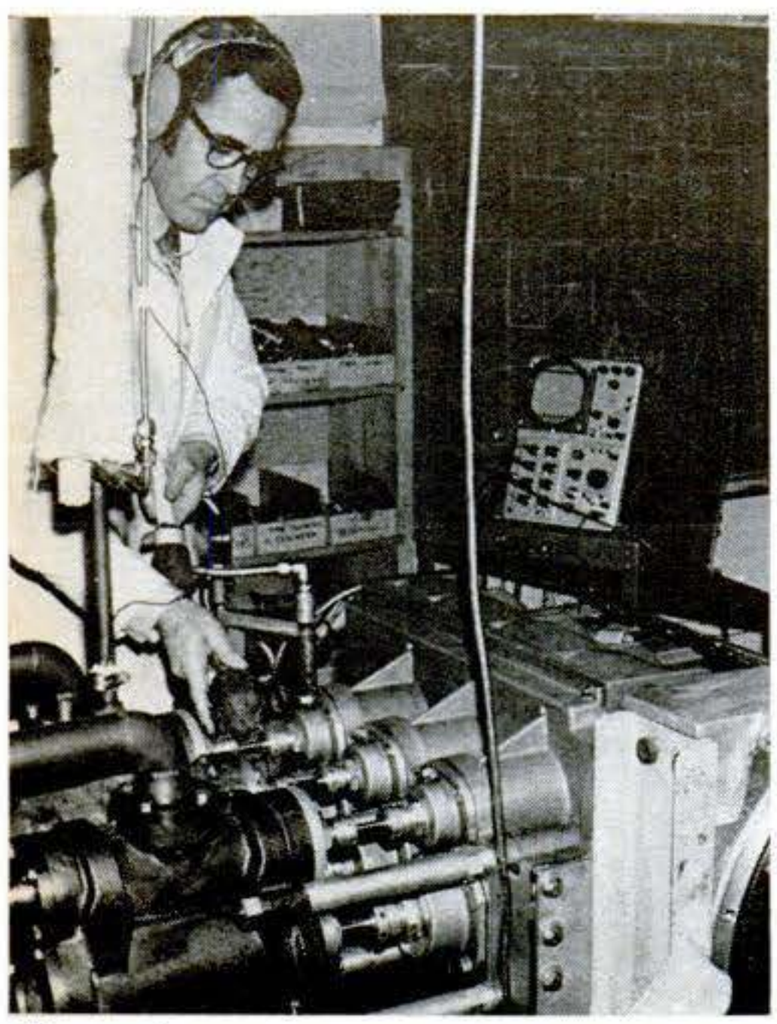
The expander, which drives the rear axle, is located amidships, underneath the floor. The steam generator occupies the space in the tail vacated by the GM diesel engine. Fuel tank is placed in front.



THE STEAM STORY: PART TWO

Steam Buses Are Rolling



Electronic tests are made by Brobeck engineer Francis C. Younger, with the expander running on a dynamometer.

Will a GM bus converted to an external-combustion power system show the way to clean-air public transport?

By JOSEPH P. ZMUDA

A few months ago, an ordinary-looking bus rolled out of a garage in Northern California. If there had been any bystanders, they would have noticed from the absence of diesel noise and fumes that it was anything but an ordinary bus. It was one of three GM coaches that William M. Brobeck and Associates of Berkeley, Calif., have equipped with steam engines. It was tested, and delivered for passenger service to the Alameda-Contra Costa Transit District of Oakland, Calif.

Inception of the steam bus program goes back to 1968 when the California State Assembly, disturbed by continued air pollution, voted to investigate external-combustion power plants. The Urban Mass Transit Authority of the Department of Transportation then made available $1.2 million to build three steam buses.

The objective is to evaluate operational feasibility, potential advantages, and public acceptance of the steam buses. The engineering task was the minimizing of exhaust pollutants, smoke, odor, and noise, while retaining the road performance of the diesel that's normally used in the GM buses.

Brobeck was not alone in this project. Other engineering firms participating are Lear Motors Corp., of Reno, and Steam Power Systems, of San Diego. Surprisingly and disappointingly, the power plant in the Brobeck-converted bus contains no new

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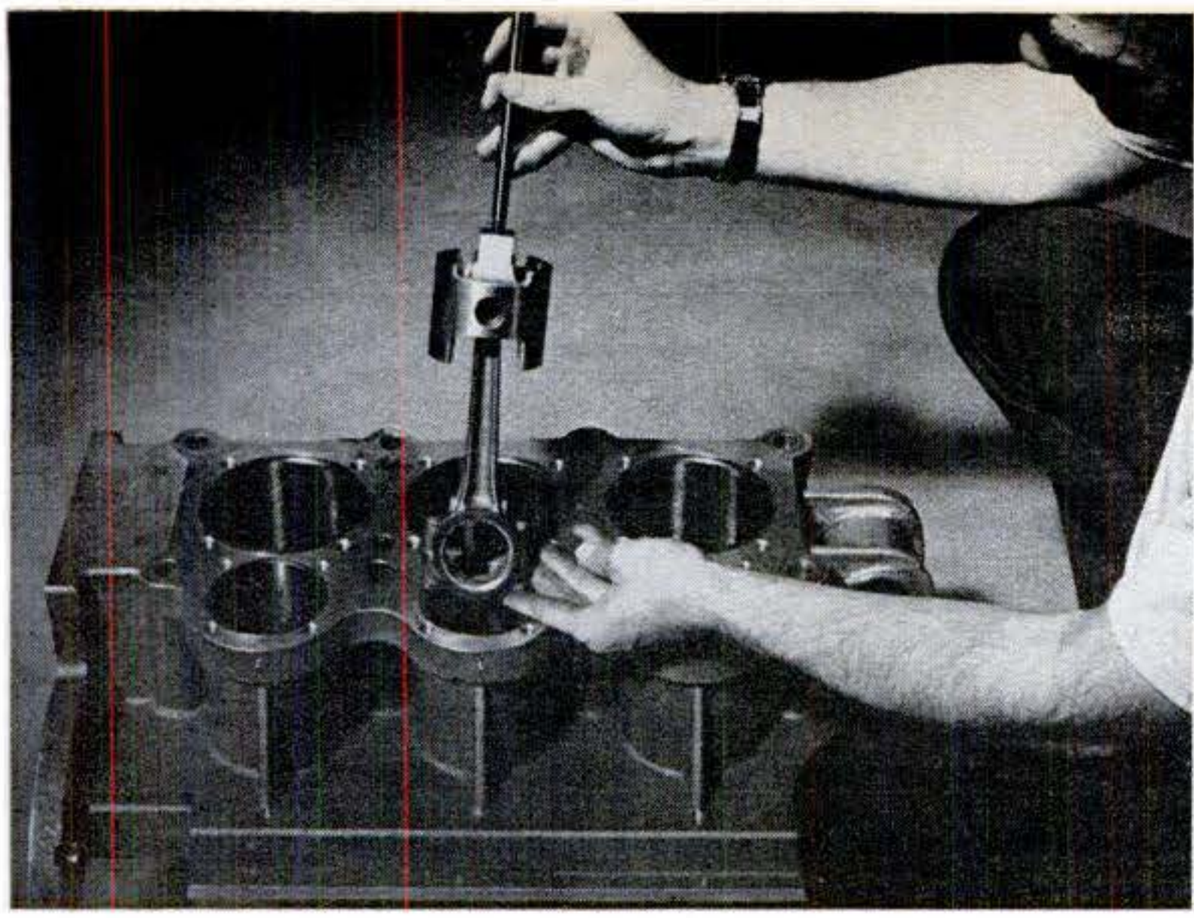
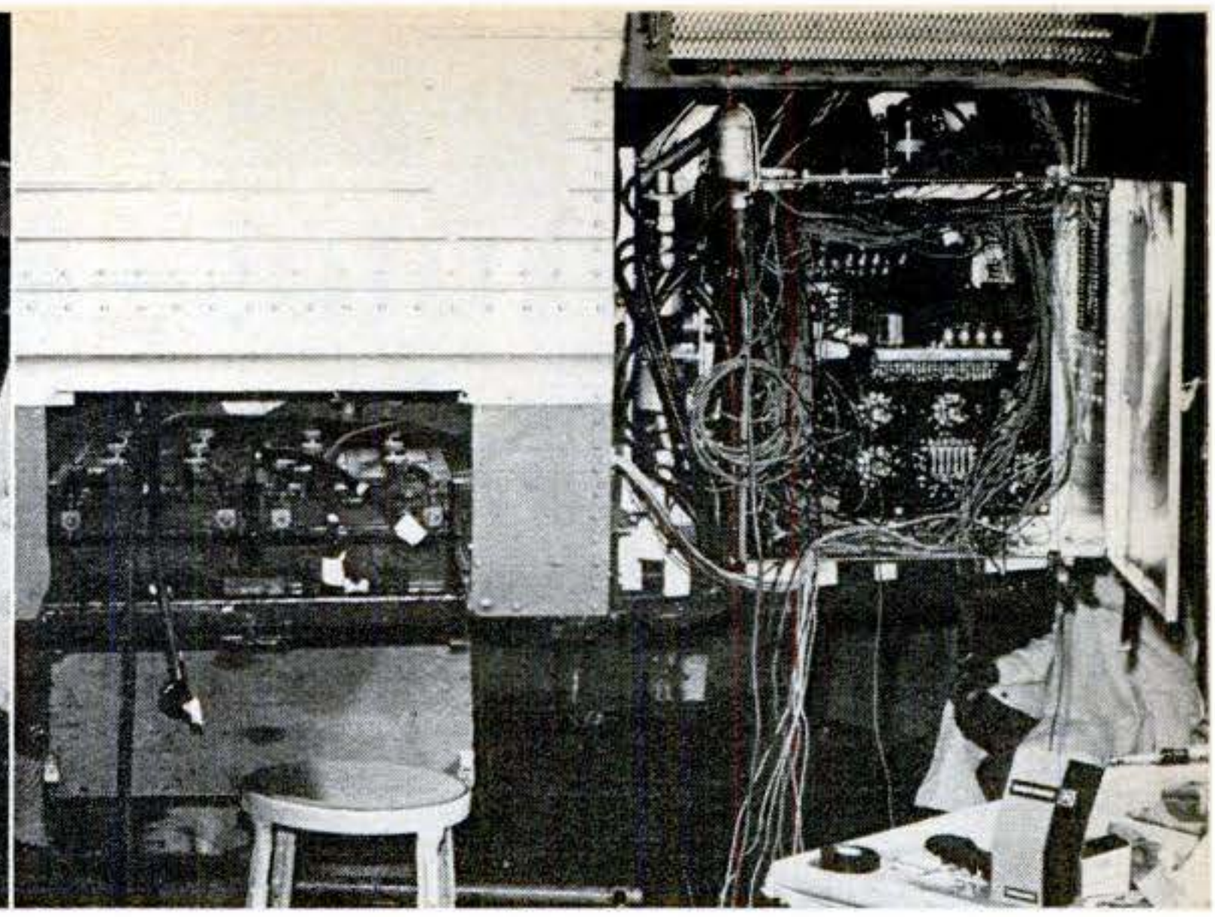


Connecting rod and crosshead piston is shown by author above the cylinder of the high-pressure valve assembly. The rod atop the piston will be attached to the high-pressure piston valve.



Over a hundred control wires run from the front of the bus to the rear connection panel (shown here). More than a mile of wiring was used by the electricians. Batteries are at lower left.

technology. It adheres mainly to the principles of the Doble steam systems developed more than 40 years ago. The only advanced technique an engineer might notice is the use of electronics (and some automatic controls).

The steam-generation system. It's the bulkiest, most costly, and perhaps most important part of a steam vehicle. Here, you find a five-foot-high, three-foot-diameter flash-type vapor generator that weighs 1,660 pounds. It is placed on its side, with the flames of a diesel-fueled burner running horizontally across the coils.

The expander is mounted under the bus floor, along with the air compressor, alternator, feedwater and booster water pumps, and a fixed-displacement hydraulic pump. Hydraulic motors turn the cooling fans of four steam condensers also positioned under the floor. About 45 hp are consumed by these auxiliaries.

Water from a 30-gallon tank is fed to the "cool" side of the vapor generator. As the working fluid moves through the helical coils toward the source of the burner flame, it turns to steam at a pressure of 800 psi and a temperature of 850 degrees F. The steam passes through a throttle actuated by the accelerator pedal and, along with injections of lubricating oil, enters the three-cylinder double-acting compound expander.

The superheated vapor is admitted alternately to either side of the high-pressure piston. As the steam expands, it is exhausted into two larger low-pressure cylinders that help boost engine efficiency.

Power to the wheels is taken from the crankshaft through a Spicer two-speed automatic torque converter transmission. The power plant is rated at 250 hp, which exceeds the output of the standard GM diesel.

What do you get? It should be a cinch to reach the required 55 mph top speed. But fuel economy is expected to be poor; perhaps as low as two or three miles per gallon. Some questions come to the fore:

Is it clean, though? Low-emission claims of 0.2 grams per mile of unburned hydrocarbons, 1.0 g/m of carbon monoxide, and 0.4 g/m of nitrogen oxides are being tested now.

Is it silent? The sound of combustion is like a thousand blowtorches lit at once, and makes you wonder who started the silent-steamer myth. There is also a low-frequency throbbing during combustion that sets up sympathetic vibrations. Still, the overall noise is less than the thunder and knock of a diesel.

Does it start immediately? Steam is produced within 10 seconds, and the bus can be moved after 30 seconds, but full power is not available for at least 90 seconds.

Is the system automatic? That's one snag. A trained engineer rides the bus with the driver, to "steam up" and handle contingencies. This is acceptable for experiments, but it would kill the bus dead for regular passenger service. What we have here is a steam bus that runs, but makes no contribution to the advance of steam-engine technology. PS

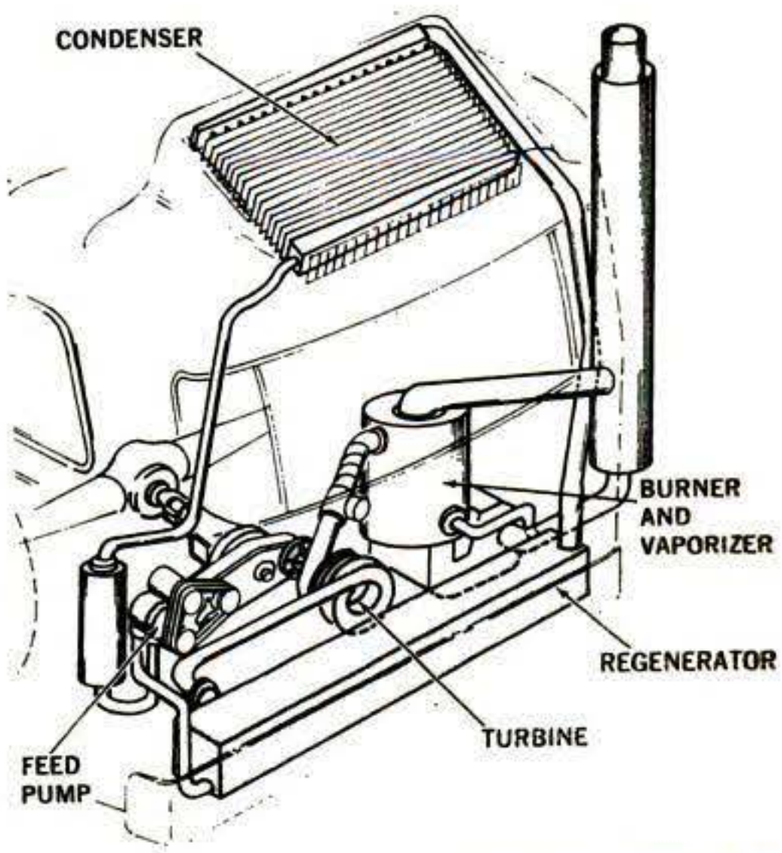
LTV Steam Bus Is Powered by Sundstrand Turbine System

In Dallas, another steam bus project is "on schedule," according to W. T. Marshall, Project Engineer for Vought Aeronautics. This is a prototype 25-passenger vehicle for experimental use by Dallas Transit under the auspices of the U.S. Dept. of Transportation. In early '72, the Rankine-cycle turbine power plant from Sundstrand Aviation, the bus from Highway Products, and the expertise of Ling-Temco-Vought will come together for the first time. Minimal exhaust pollution is expected, but this, too, will be tested. Some noteworthy aspects of the Dallas bus:

- Emphasis on simple, rugged, workable components for this first bus, at least.
- CP-25, toluene expanding fluid rather than water or Freon.
- A modified torpedo turbine with a long and successful history for the basic power plant.

Important, here, is Sundstrand's practical experience with over-the-road transmissions. It seems likely that their dual-mode hydromechanical transmission, developed for turbines, will be a key piece of hardware in matching the high-speed power of the turbine to the low-speed lugging power needs of a city bus.

In fact, the confidence of LTV and Sundstrand engineers is such that the power complex will be assembled and run for the first time in the bus without benefit of test-bed experiments. PS will report the progress of the Dallas bus as it all comes together.—E. F. Lindsley



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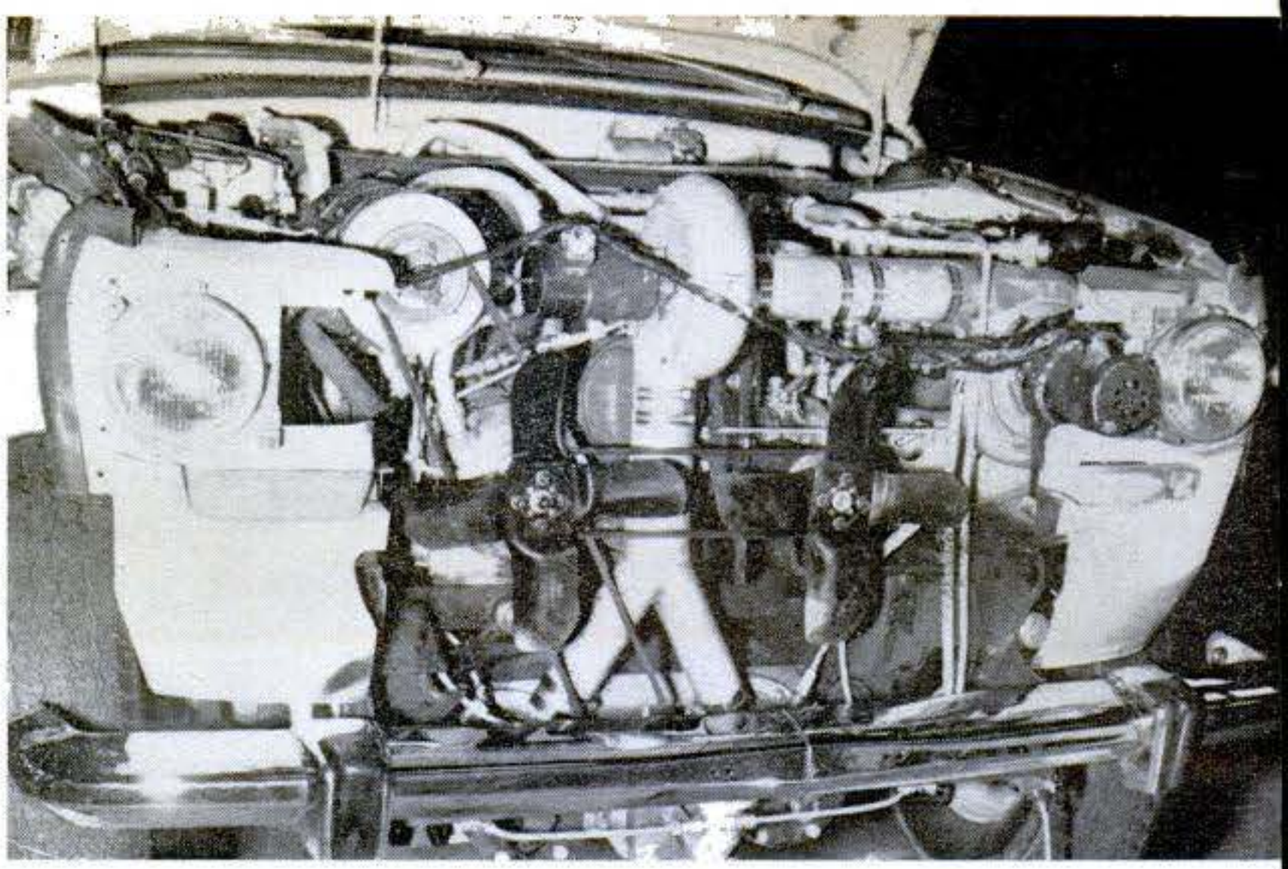
THE STEAM STORY: PART THREE

Steam Autos—Dead End or Sure-Fire?



Minto external-combustion engine installed in Datsun car shows blowers and motors adapted from aircraft hardware.

The search for a breakthrough in external-combustion technology forges ahead

By E. F. LINDSLEY/*PS Midwest Editor*

POPULAR SCIENCE has watched and will continue to watch the widely scattered but unceasing efforts to produce an external combustion (EC) vehicle. The quest is on, in backyard shops, college labs, and industrial research firms, with experimental engines, computer runs, and actual test vehicles attesting to the effort. The goal: a prime mover not cursed with the internal combustion (IC) engine's noxious exhaust, which now lies heavy on the land.

If the test results of Wallace Minto, inventor of the fluorocarbon car reported last year [PS, Oct. '70], the Du Pont organic-fluid engine, in a preceding article, and others can be realized in practice, the toxic carbon monoxide and smog-making nitrogen products can be eliminated by EC. The exhaust of an efficient EC burner is mostly carbon dioxide and water.

What are the problems? What's holding things up?

- The giant leap needed to bridge 50 years of steady refinement in IC engines and in a short time build a publicly acceptable comparable car.
- The enormous financial gamble for research, prototypes, testing, tooling, and marketing.
- The lock-in of major car makers on long-range tooling payouts, sales traditions based on consumer reactions to superficial model changes, and the financially unacceptable probability that starting with a new prime mover would entail massive money losses for several years.
- Nonexistence of hardware to do specific jobs in EC systems.

Moreover, there is always the good possibility that the unwillingness of car builders to promote EC may prove sound judgment. After all, no one in recent years has produced an even reasonably successful steam vehicle. Shortly, however, we expect the steam buses in California and Dallas [see preceding article] to be on the road.

Importantly, the buses, which at best can be little more than assemblages of hand-built parts and make-do hardware, won't be dumped on consumers who might expect '72 car perfection. Instead, men who know technical problems will keep sight of engineering objectives without being disturbed by minor nut-and-bolt items. Also, should pollution ultimately make it necessary to limit the IC passenger car, nonpolluting bus transit could take over in metro areas. Cars, with pollution controls, might then operate only in open areas.

The report on the Brobeck bus confirms that an EC prime mover is unlikely to compete in total detail with a modern IC engine. One reason: An engineer may often be aware of existing solutions to a certain problem—noise, for example—but bypass it in favor of stickier problems. Du Pont does this with their burner.

"System" or total package. This is the crux of the challenge. It starts with the search for the right expansion medium. No liquid appears to beat water for energy-carrying ability. But water freezes, warms and cools slowly, scalds if a boiler bursts, and varies widely in mineral content and chemical treatment needs when used in a boiler.

Anti-water engineers point to nonfreezing fluorocarbons, toluenes, and other exotic chemicals that are even now serving as expansion mediums. These agents, admittedly, are made with processes which consume large amounts of power and in themselves may produce undesirable pollutants.

There is a multitude of mechanical expanders (engines) able to accept gas under pressure and convert heat into mechanical power to turn wheels. Simplest are the piston engines, often double-acting or compounded. The turbine has a long and honorable history. Numerous cam engines, swash plate ideas, and complex linkages are also available. Thus, the engine seems no problem.

Boiler problems. The boiler wherein the working fluid is converted into high-pressure gas *is* a problem, and so is the condenser to change the gas back to liquid. Presumably, it is possible to heat the boiler with a burner fired by fuel oil, propane, or perhaps LNG (liquid natural gas). Matching road needs from slow traffic to highway speeds will be tricky if favorable exhaust characteristics are to be maintained.

But the boiler has even more severe requirements. It must be:

- Safe—regardless of accidents, poor maintenance, or user ineptitude.
- Efficient—small, but able to provide instant steam for the necessary traffic response.
- Rugged—to take the highway jars and jolts.

The Hornbostel boiler [PS, Nov. '71] and the Du Pont rotary boiler are good bets.

For the Rankine cycle to use the same fluid over and over, as in a refrigerator, a condenser must exchange excess heat to the air. One way is by massive radiating surfaces with cooling fans. Such units tend to be huge and the fans soak up power. The rotary condenser used by Du Pont now looks more attractive.

EC power offers some plusses . . .

- Positive displacement expanders might eliminate transmissions.
- Noncritical fuels; no lead.
- Long engine life and fewer mechanical troubles.

None of the problems appear insurmountable. The two new buses, or Du Pont's new engine, can be very important, if tentative, steps toward reducing automotive pollution. PS

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Super-Accurate Thousand-Dollar Quartz Watches...

Now There's One Under $200!

Here's the ultimate in timekeeping: Watches below are among the first models to appear in the U.S. Produced in limited quantity, all are slightly larger and heavier than conventional watches. Timex' new quartz was not available for this photo.

They hum like amplifiers, and their vibrating crystals insure accuracy of seconds a month

By OSCAR SCHISGALL

"The most accurate timepiece ever devised by man." That's how watch makers describe the newest thing in timekeeping: the electronic quartz watch. Some also call it "the most important new way of measuring time developed in more than 200 years."

Sound wild? It's not an exaggeration. The electronic quartz concept is so different and important that the watch industry may never be the same again.

Big problem with quartz watches until now: They're terribly expensive. The first models coming out of Switzerland and Japan start at $595 in stainless steel, go up to $2,200 in gold. That's why they've been manufactured in limited quantities and only a few have been sold. Now Timex has announced a new model scheduled to go on sale late next month. The price, as of this writing, is estimated at somewhere between $150 and $185.

What's an electronic quartz watch? How does it differ from others? How good is it? Let's take these questions one at a time.

The quartz watch is based on a principle entirely different from those of all other watches. Most watches rely on the familiar balance wheel. A carefully balanced spring-driven wheel rocks back and forth at a rate (usually five times a second) determined by its size and weight. The accuracy with which it maintains that base rate largely determines the watch's accuracy. A top-quality balance-wheel movement keeps accurate time to within perhaps four minutes a month. The tuning-fork concept is more sophisticated. The tuning fork, much like the one the piano tuner uses, vibrates or oscillates 360 times per second; and it results in a watch that's accurate to within a minute a month.

The quartz watch completely abandons the *mechanical* time-regulating device—balance wheel or tuning fork. Instead, it uses an electronic oscillator much like the one that controls the frequency of a broadcast station. The frequency of this oscillator—exactly as in a radio station—is determined by a bar-shaped sliver of quartz. Most quartz watches use quartz oscillators

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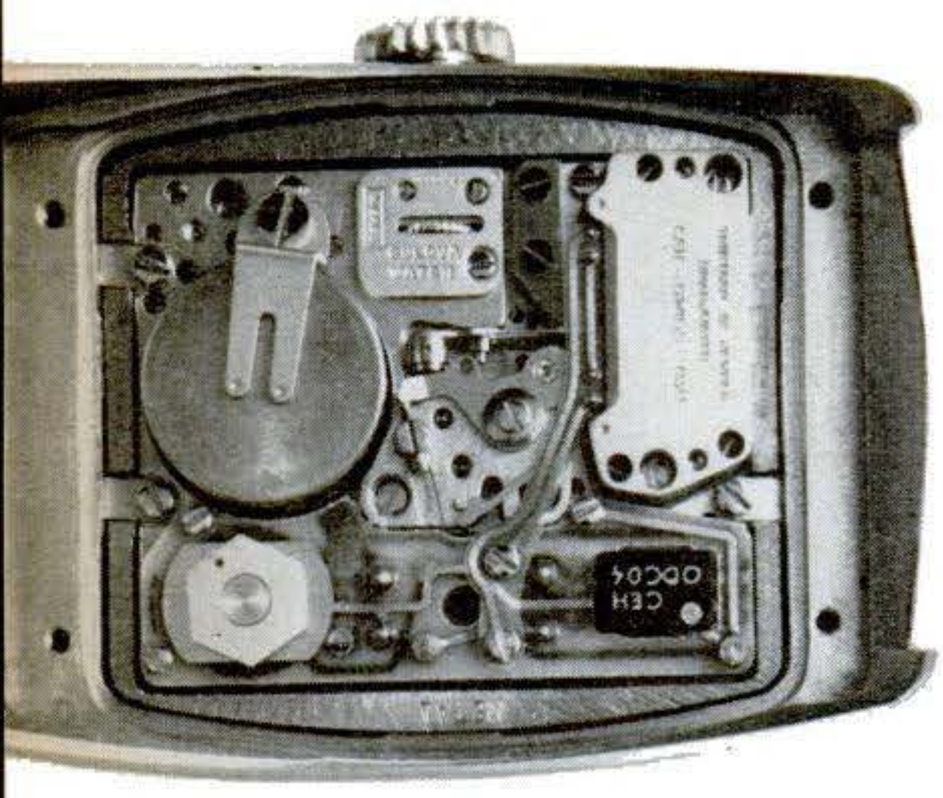
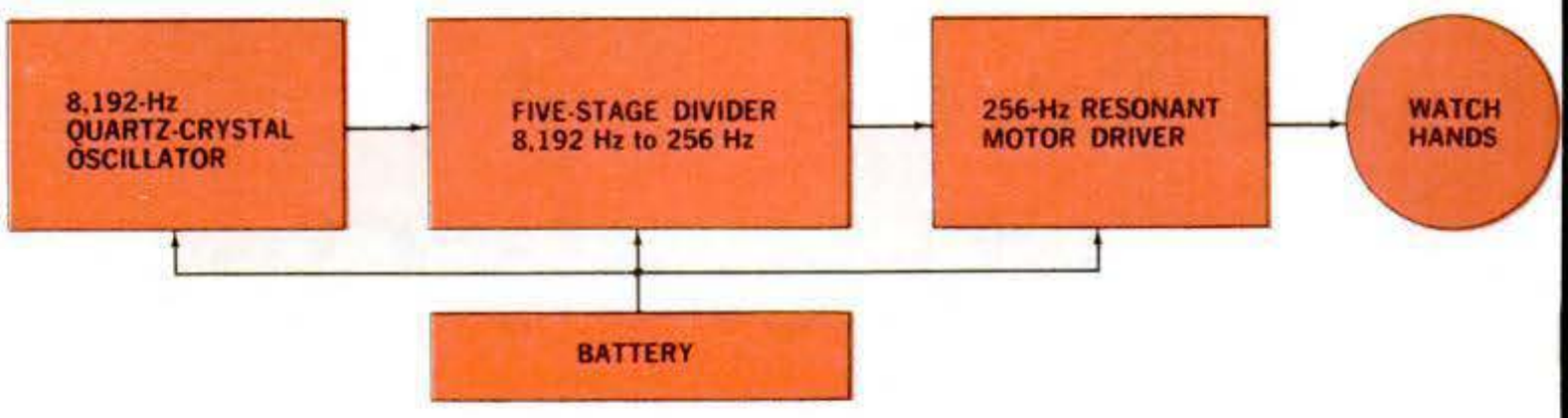
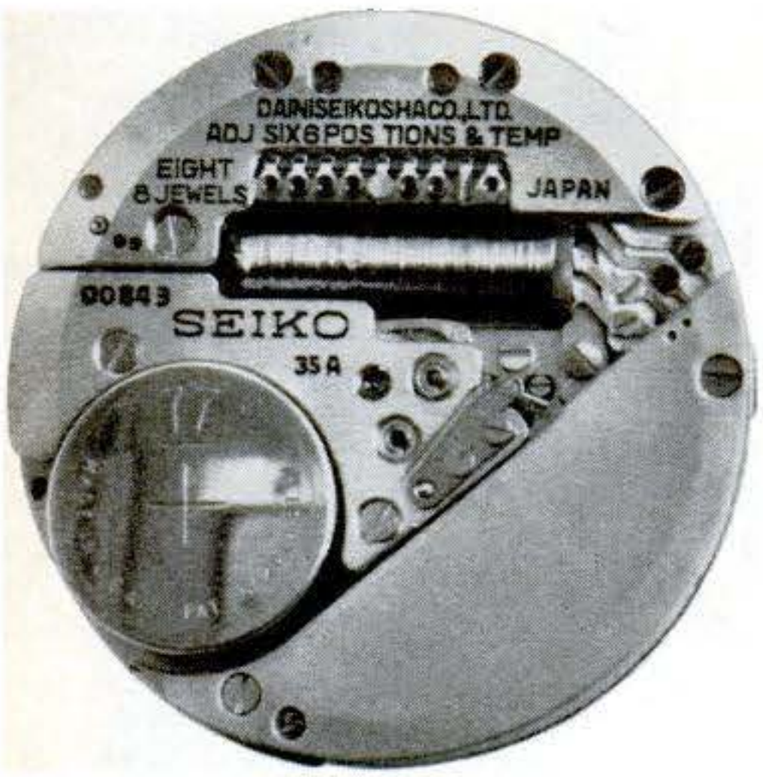
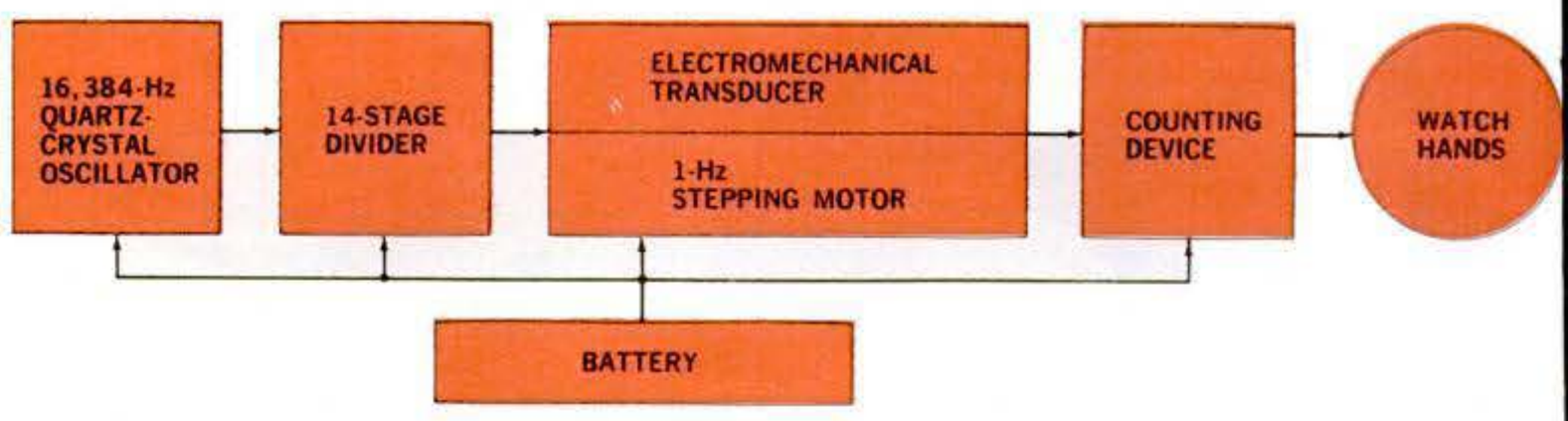
There are at least two reasons why the Timex is so much cheaper — advanced





SWISS-CEH **The Swiss Center** of Electronic Horology developed this quartz watch for its member companies, among them Bulova and Omega. The 8,192-Hz quartz oscillator goes through a five-stage divider in a micro-electronic integrated circuit. The resulting output is 256 Hz. This frequency goes to an electromagnetic motor which further divides the pulse into one-second intervals. Using this pulse, the wheel train turns the hands. Omega's integrated circuit contains 21 transistors and 61 other electronic elements. Member companies in the CEH organization may alter the basic movement slightly to fit an individual watch case.





SEIKO **This quartz** has five major components: 16,384-Hz quartz-crystal oscillator circuit, integrated circuit with a 14-stage divider, stepping motor with an electromechanical transducer, and silver-oxide battery. The divider circuit halves the 16,384-Hz frequency 14 times (8,192; 4,096; etc.—down to a single pulse). The electromechanical transducer converts the one-pulse signal into mechanical motion, to turn the six-pole stepping motor in 60-degree increments. Finally, the counting device moves the second hand at exact one-second intervals. Pulling out the crown stops the second hand, for precise control. Battery life is claimed to be one year.

with 8,192 Hz—vibrations per second. If you listen to a quartz watch, it hums like a tuning fork—but it's far more accurate.

Quartz, the familiar transparent crystalline mineral, is a remarkable substance. It has piezoelectric characteristics. If a voltage is applied across a slab of quartz, it bends slightly. Put the quartz in an oscillator circuit and it will vibrate at its natural frequency, which is determined by its size and shape.

This natural oscillation frequency is so precise that quartz watches are accurate to within seconds per month. Most quartz-watch makers guarantee accuracy to within five seconds a month; the Timex people conservatively claim an accuracy of 15 seconds a month.

How they work. Most quartz watches operate on the same general principle. (Longines work differently; Timex, we can't say.) First, you have a quartz-crystal oscillator circuit. Next, a small mercury or silver oxide battery to provide voltage so the quartz can oscillate. But the quartz crystal's natural vibrating frequency is too high; more manageable speeds are needed to move around the hands.

Micro-electronic integrated circuits come in here. "Dividers" in these circuits "step down" the frequency by halving it several times (8,192 frequency is the 13th power of $2-2^{13}$). The number of dividers in the circuit depends on the quartz-crystal frequency and other circuitry a particular company uses.

Whether the pulse is divided down to one pulse or a slightly higher frequency (256 in the Swiss movements), an electro-mechanical motor receives the pulse and converts electrical energy to mechanical energy. This drives the wheel train that eventually turns the hands. Of course, each company's watch works a little differently. (See explanations above.)

Still, the big mystery is why the Timex is so much cheaper—between a third and a quarter of the price of its nearest competitor. Undoubtedly, there are at least two reasons.

First, a technology geared to enormous production. "We have developed mass-production techniques unmatched outside the United States," says Joakim Lehmkuhl, president of Timex. "You can't produce 19 million watches a year, as we've been doing without learning a great deal about automated mass production and methods of cost control. When it came to actually manufacturing the quartz watch we already had a backlog of experience in essential fields like the design and manufacture of parts, especially miniaturized parts."

Timex produces all the parts in its watches—except the quartz-crystal oscillator and the circuit. At Waterbury, Conn., I watched skilled workers assemble the watches.

My guide, an engineer, pointed out that in the field of conventional watches, Timex has been manufacturing pin-lever movements, which are less expensive to produce than the Swiss and Japanese jeweled movements. But he, like the others I talked to at Timex, would not agree that their quartz-crystal watch used a basically less-advanced mechanism than its competition. This leads directly to the second reason for lower cost.

Despite the lack of any available proof, Timex has apparently figured out some way to simplify the design and reduce the cost of building a quartz-crystal watch with a super-

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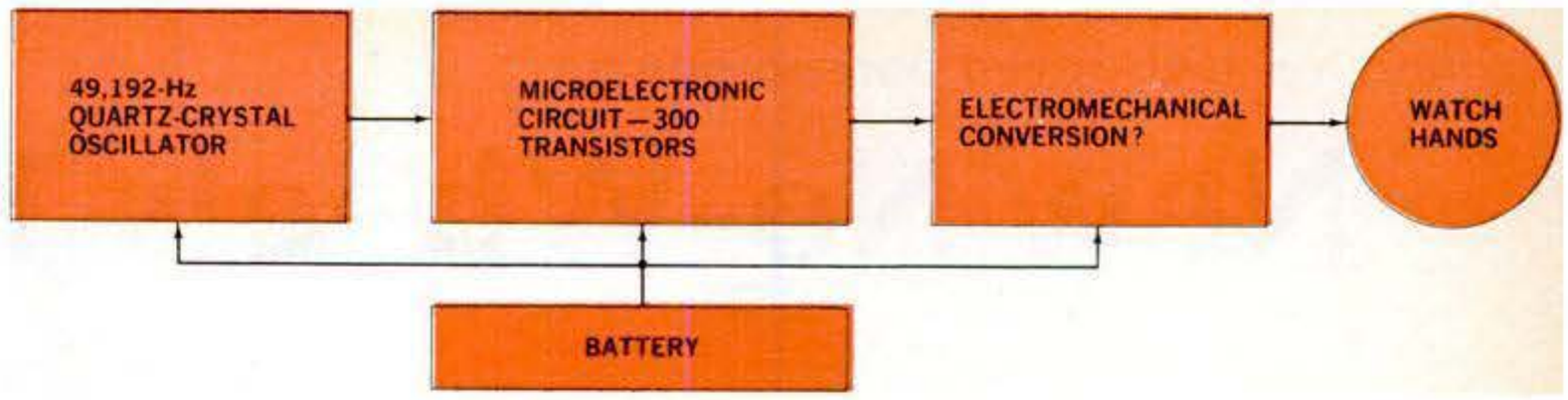
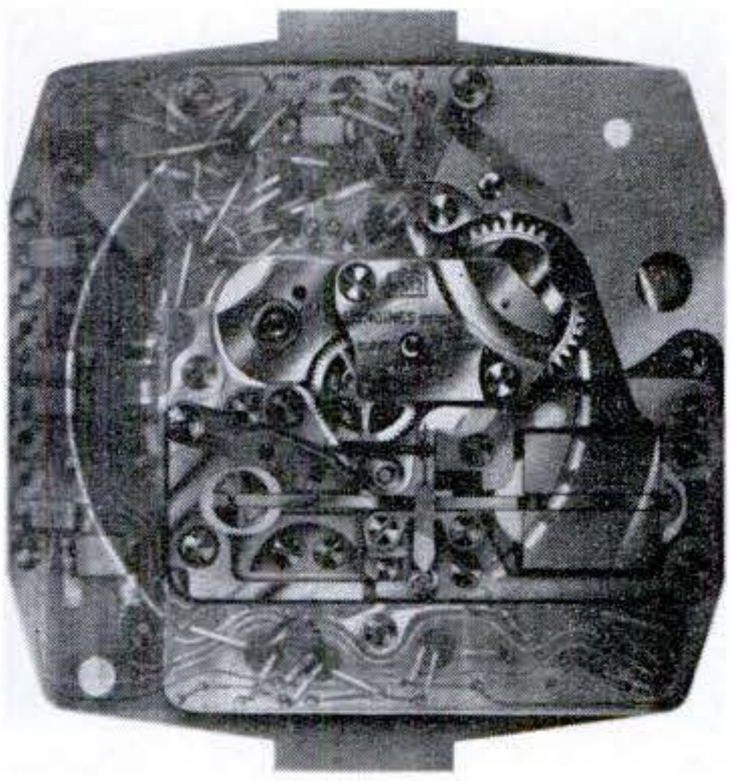
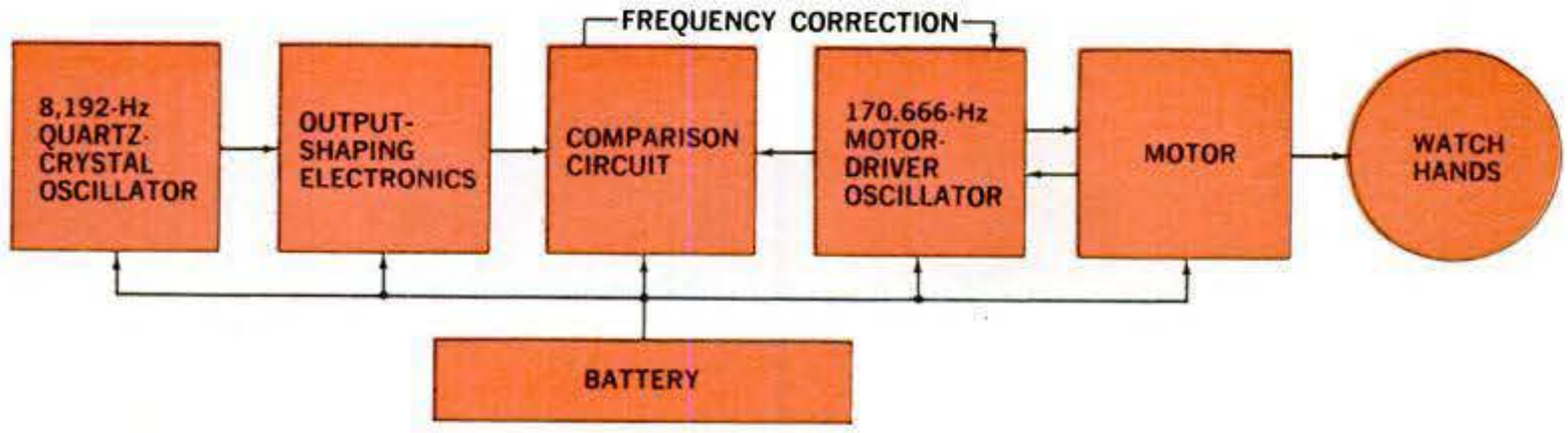
mass-production technology and a circuit that's still top secret



TIMEX **What's inside?** We don't know yet. At press time the technical information was still "top secret." We do know that the Timex movement uses a crystal oscillator with a 49,192-Hz frequency—far higher than any other quartz on the market. This frequency is not a power of two as in the others—which makes it even more mysterious. It has a micro-electronic circuit—about one centimeter square—containing 300 transistors. It also uses a silver-oxide battery good for a year. It could have several things in it—including some kind of comparison circuit, or a digital or analog means of controlling the watch's speed. It's accurate to 15 seconds a month.





LONGINES **This one's unique:** A comparison circuit detects error in the watch's output and self-corrects. A 9,350-Hz quartz oscillator is the frequency reference—which is not divided, as in other watches. A 170-Hz servomotor, independent and operating by itself, turns the hands. Mechanical output is compared with the quartz signal. If there's an error signal in the comparison circuit, a correction is applied to the motor. If motor frequency and crystal frequency are in step, the error signal is zero. The circuit has 14 transistors, 19 resistors, and seven capacitors. Insurance against loss or theft for one year comes with the watch.

high frequency. The company has apparently made an important breakthrough in quartz-watch technology—one that gives it a tremendous advantage—and company engineers and executives are understandably reluctant to reveal their secret.

Although the Timex people showed me various versions of their watch, they refused permission to photograph it—face or movement. Nevertheless, Timex executive vice-president Robert Mohr did give POPULAR SCIENCE some exclusive technical information, emphasizing that "our watch, as far as I know, is entirely different from any other quartz watch." This, along with our speculation of what's inside it, is above.

How about watch performance? Reliability? "Since there are virtually no moving parts," says Lehmkuhl, "very little can go wrong. We have put the watch through every conceivable test of temperature, altitude, and humidity. We have made every test for position error—dial up, dial down, three o'clock up, six o'clock up, nine o'clock up. Where we found bugs we corrected them."

And shock and water resistance? "Water resistant, yes. As for being shock resistant...," Lehmkuhl smiled. "It is sturdy, but we don't recommend that you hurl it against walls as we did in torture tests with our conventional watches. We wouldn't recommend such treatment for any item that costs over $100."

In any event, Timex seems destined to be the first to market the new watch in quantity, and Seiko threatens to be a close second. Why aren't the Swiss (such as Bulova, Omega, Longines, and others) marketing quartz watches in large numbers?

Tuning-fork watches. Bulova has had a lot of success with its Accutron tuning-fork watch. Now other Swiss companies have been licensed by Bulova to make tuning-fork watches. As one Swiss manufacturer said, "We want to make the most of our tuning-fork watch, which represents a heavy investment. Time enough for the quartz watch when the tuning-fork has passed the peak of popularity."

Another predicted differently. "Timex and its advertising campaign for the quartz watch may well be the catalyst that will compel all of us to jump in and compete."

I asked Joakim Lehmkuhl of Timex how far away he thought the era of the quartz watch might be.

"We don't expect a hundred million Americans to throw away their watches tomorrow morning in order to buy a quartz watch. We are dealing not only with watches, but with human nature. We expect, as new watches are bought, that purchasers will want the latest and most accurate type. Simply because the quartz watch is unquestionably the newest and most accurate example of horology man has so far achieved, we are confident that it will be, if not the dominant watch of tomorrow, surely that of the day after tomorrow."

And what can we expect, the day after *that*? Nuclear timekeeping. Some day you may be able to buy a watch containing a milligram of an alpha-particle-emitting radioactive isotope as a power source. It may be accurate to within a few seconds a year—almost as accurate as the movement of the Earth itself! Although Bulova's engineers are already exploring nuclear timekeeping, they believe it's a long way off. Name? What else but the atomic watch? PS

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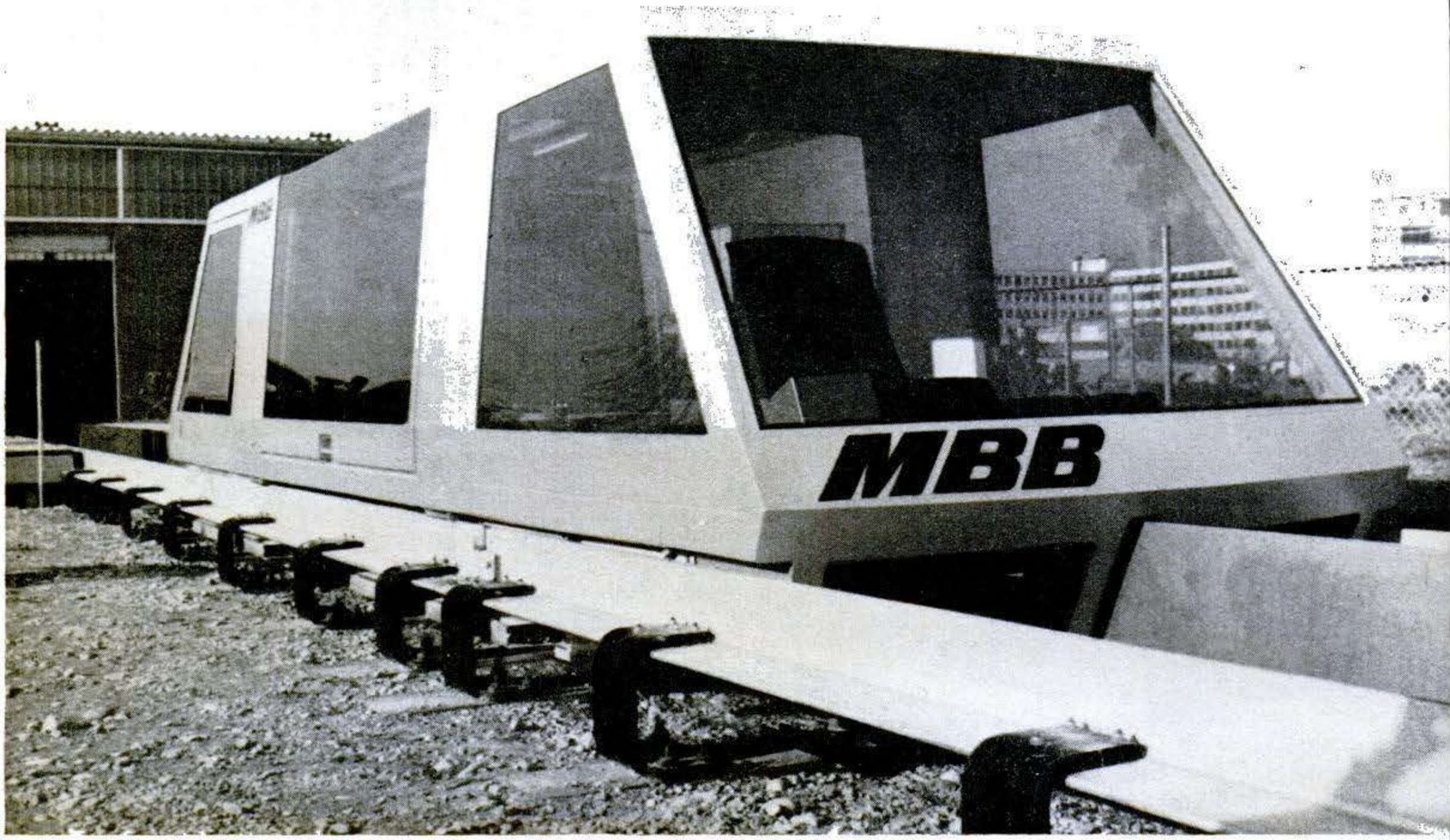
Is this experimental train the key to safe, silent, and economical high-speed transportation?

New No-Wheels Train Gets a



Five-ton car runs suspended by magnets from L-shaped rails elevated on U-shaped brackets. Powered by a linear-induction motor, the train has done 40 mph on this experimental track. Unevenness of test track prevents running the vehicle at its top speed.

By DAVID SCOTT / *PS European Editor*

You sit back in a body-contoured seat and fasten the safety belt. You feel as though you're about to take a ride in a solarium, the view around you is so immense.

Ahead lies 720 yards of dead-straight track. Directly in front of you the driver pushes a button on a little control box. Electrical contactors click behind you, a subdued hum fills the cabin, and the platform alongside gently falls away about half an inch.

You're airborne in the German magnetic levitation train, a vehicle that could lead the way to the high-speed rail transport of the future. This future could come quickly, and 240 mph would be just the beginning.

The driver flicks a tiny joystick forward. More contactors close, and the thrust at your back is like that in a jetliner starting a takeoff run. In seconds, the scenery is whizzing past. But there's no other trace of movement—no bounce, no jolts or vibration. And the only noise is a gentle medley of humming and rhythmic clicks as the collector shoes wipe along the power rails.

This new form of surface transportation could rival aircraft on real intercity run time; leapfrog tracked hovercraft on operating cost, performance, and comfort; and offer more safety than wheeled rail cars. Developed in Munich by Messerschmitt-Bölkow-Blohm, West Germany's largest aerospace group, the experimental five-ton railcar is suspended by electromagnets, and propelled by a linear induction motor.

No moving parts. In the entire vehicle there is nothing to wear or make noise. And there is no physical contact with the track other than the collector shoes. It's all done with magnetic fields.

Now our driver flips the joystick to neutral. We're defying gravity in a frictionless coast. Only wind resistance slows the car. While we're floating forward at a good clip, the driver pulls back the stick to reverse, and we lurch forward against the seat belt. The linear motor—trying to run backward—is dragging against the fixed reaction plate for powerful, silent braking.

Patented back in 1937, the idea of magnetic suspension is starting to move. Alert to the tremendous potential, MBB has in less than a year raced from the drawing board to a man-carrying test vehicle. The project was speeded by government money, and by drawing on top brains in missile and space technology.

The basic concept is ingenious. L-section steel rails raised a foot above sleepers on U-shaped brackets form the track. The car is actually suspended beneath the two rails by electromagnets on its frame. These face upward and pull against the flat track undersides, but don't touch them. When these magnets are de-energized, the car sets down against the tops of

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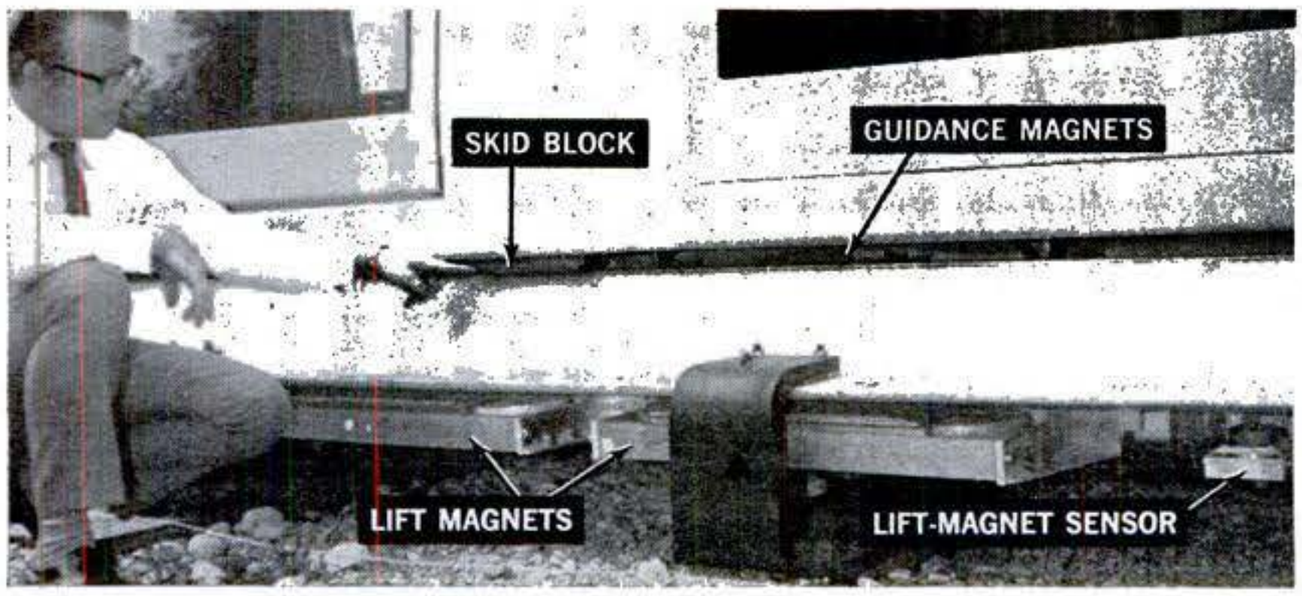
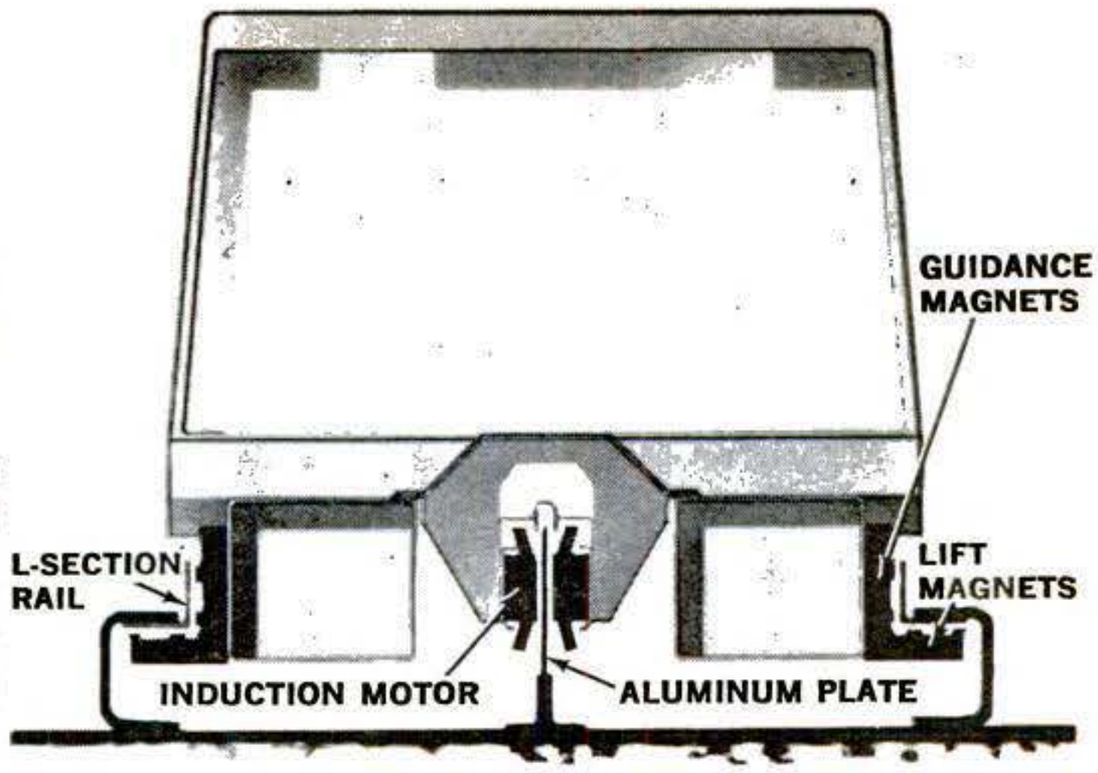
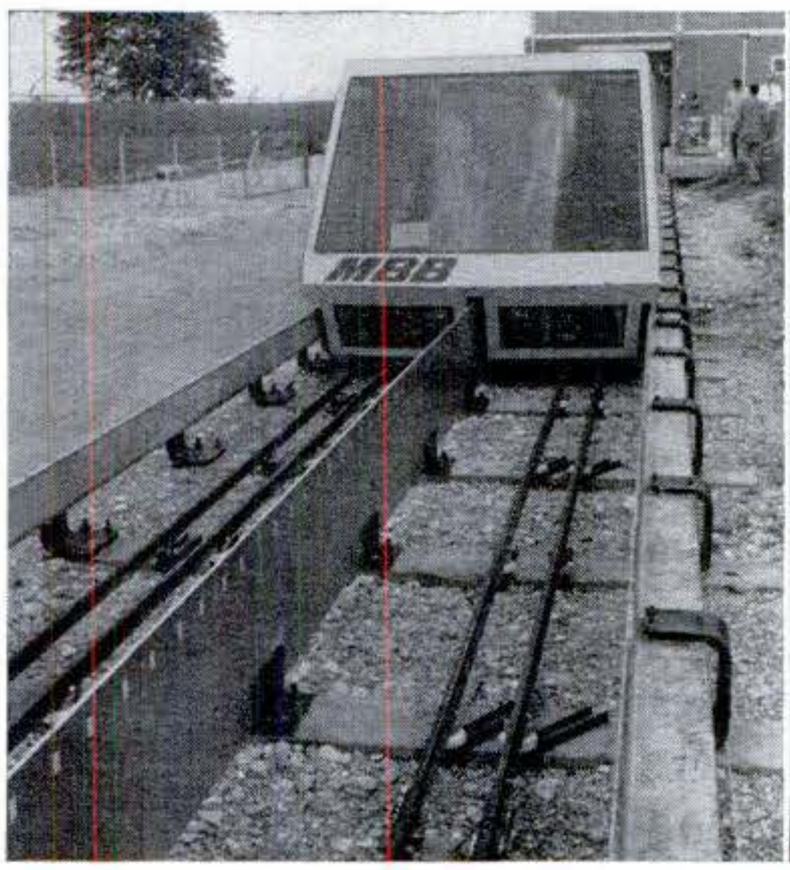
Lift from Magnets





How it works: Above, lift magnets pull against L-section track to elevate car. Vertical-guidance magnets work against rail's vertical faces to keep car centered in tracks. Induction motor reacts against stationary aluminum plate to drive car and to apply braking force. At left: array of magnets and the sensors that control them.



Vertical aluminum plate is "rotor" of motor; the four dark rails carry 380-volt current.

Wide-angle view from cab of train is impressive. Driver has hand on joystick for speed control and braking. Pushbuttons control lift and guidance magnets.

the rails on skid, or parking, blocks.

Lateral guidance is by a separate set of upright magnets facing and drawn to the vertical surfaces of the L section—again without contact.

Straddle-stance motor. Centered in the car frame is the linear motor with its flat parallel "stator" windings. Formed like an inverted U, it straddles the two-foot-high aluminum plate running down the center of the track. This stationary reaction element is the "rotor."

Since the stator windings are flat, instead of cylindrical as in a conventional motor, the magnetic field moves in a straight line rather than in a circle. It thus induces corresponding currents in the plate, imparting linear thrust to the coils.

Though designed merely to give the test car basic traction and not for brilliant acceleration or high speed, the present MBB motor still has a starting thrust of some 2,200 pounds, comparable to a small jet engine. The 174-kilowatt rating equals 240 hp, and this is enough for a 60-mph capability even on the short test track, including stopping distance.

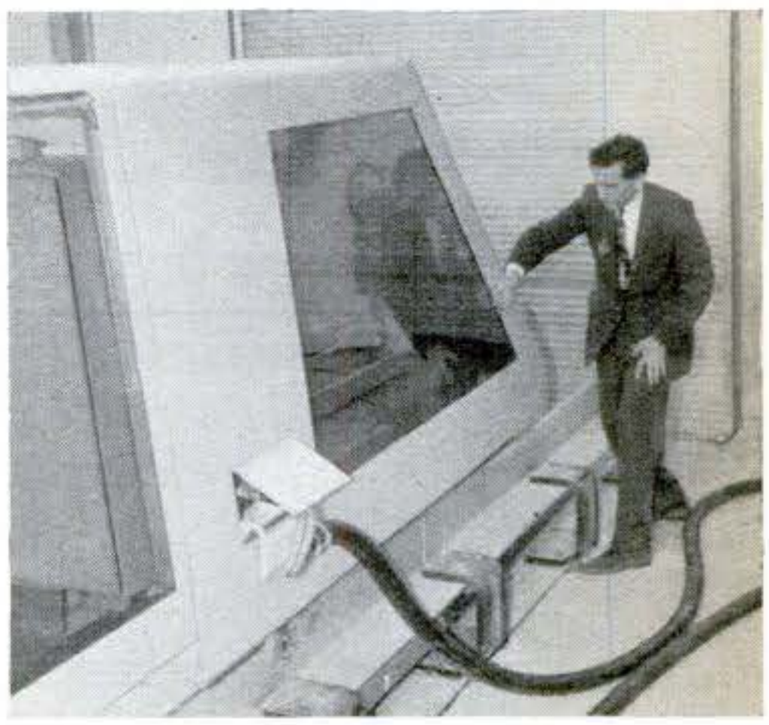
For braking at any speed you just switch over the input connections and the motor produces a reverse thrust equal to about half maximum forward thrust. That's another bonus to add to silent running and no wearing parts like bearings and brushes.

The 25-foot-long car is based on an alloy box-section frame for lightness. At each corner are one guidance and two lift magnets. Collector shoes pick up the 380-volt three-phase supply from four rails along the track. This AC current feeds the linear motor. For the magnets, it is stepped down and rectified to 60 volts DC, controlled by the voltage-regulating thyristors.

The crafty bit. The control system is what makes magnetic levitation shine. With the present setup, the normal air gap between individual lift magnets and the flat rail surface is about half an inch. But this can be varied by a quarter inch in either direction to correct for unevenness in the rail. Correction is automatic and almost instantaneous, giving an absolutely smooth ride.

Here's how it's done: Just ahead of

[Continued on page 125]



Car can be moved with his fingertips while it floats in its tracks, author finds. Inside storage shed, DC power for magnets is fed through hefty cable.

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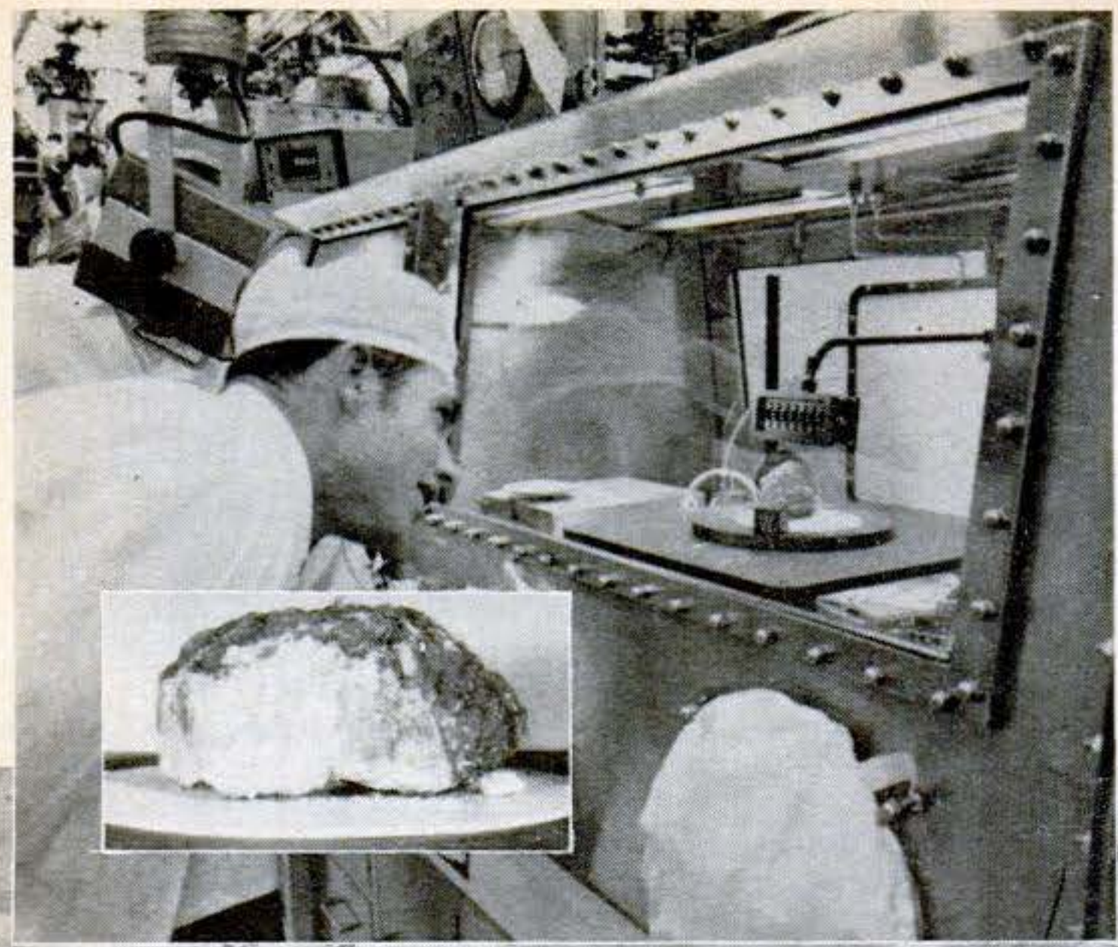
How Apollo 15 Changed



Astronaut Scott peers at a "genesis rock," which may be 4.1 billion years old. Inset shows its whitish, crystalline interior.

A spectacularly successful mission answers some questions—and raises more

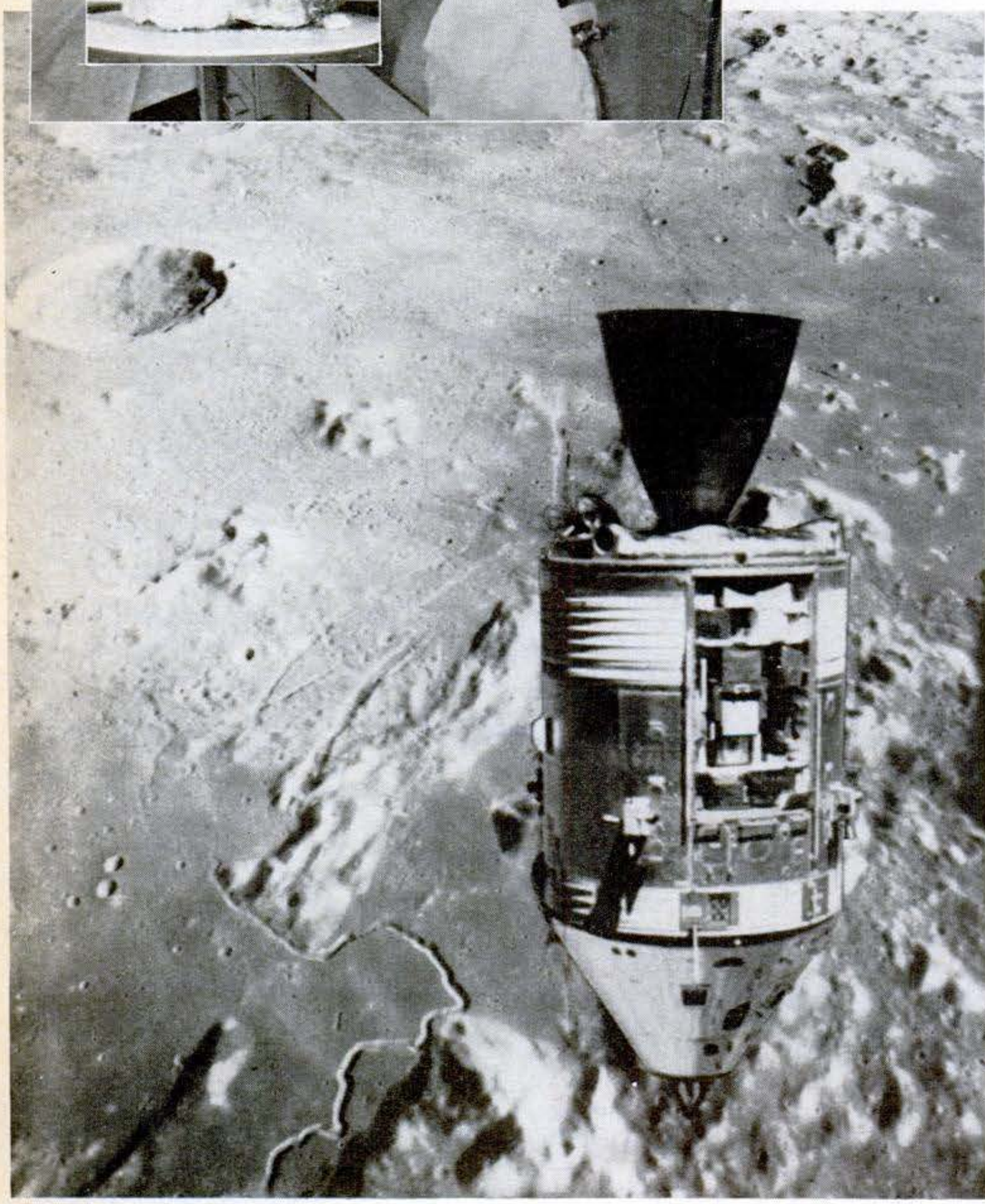
Apollo 15's list of finds and new insights is not yet complete, but already its scientific booty far exceeds returns from the trailblazing earlier missions.

The 15 crew returned with 168 pounds of lunar surface material that included 59 rock samples weighing more than 25 grams each. This is a little more than 75 percent of the combined weight of all the material returned by Apollos 11, 12, and 14.

The painstaking care that Cmdr. David R. Scott and Lunar Module Pilot James B. Irwin took in collecting and documenting their samples pinpoints 57 of the 59 rocks at precise locations on the detail map of their land excursion; 45 rocks can even be properly oriented on the basis of the photographs.

The 21 pounds of "Great Scott" basalt with 23.1 percent iron oxide has the highest iron content of any lunar rock found thus far. The whitish "genesis rock," composed almost entirely of plagioclase (calcium-sodium-aluminum-silicate), is certainly one of the most exciting finds ever made on the moon.

More than seven pounds of the samples were taken from a depth of approximately 13 inches with the five drive tubes; about three pounds were taken with the deep-drill core, which went to a depth of about eight feet.



Experiment-packed Apollo 15 above the Hadley-Apennine area (looking north). Landing site is just to right of "chicken beak" formed by Hadley Rille (bottom).

Panoramic 360-degree mosaic at ALSEP site shows Scott drilling holes for heat-flow experiment. Central-station/seismic-experiment package is at both ends of mosaic, with cables to other sensors. Moon rover is parked in front of Falcon lunar module. Pan extends

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By DR. WERNHER von BRAUN
NASA Deputy Associate Administrator
PS Consulting Editor on Space

Our Ideas About the Moon

Interior temperatures. The heat-flow experiment has yielded its first data cycle for one complete month, or one lunar orbit around the earth. Surface temperature varied between +86 degrees C at local high noon (a bit after full moon) and −185 degrees toward the end of local lunar night.

However, a mere three feet below the surface, the diurnal variation was found to be in the order of only a few thousandths of a degree! The string of temperature gauges inserted into a drill hole clearly indicated a steady increase of the temperature level with depth, at a rate of about one degree per foot.

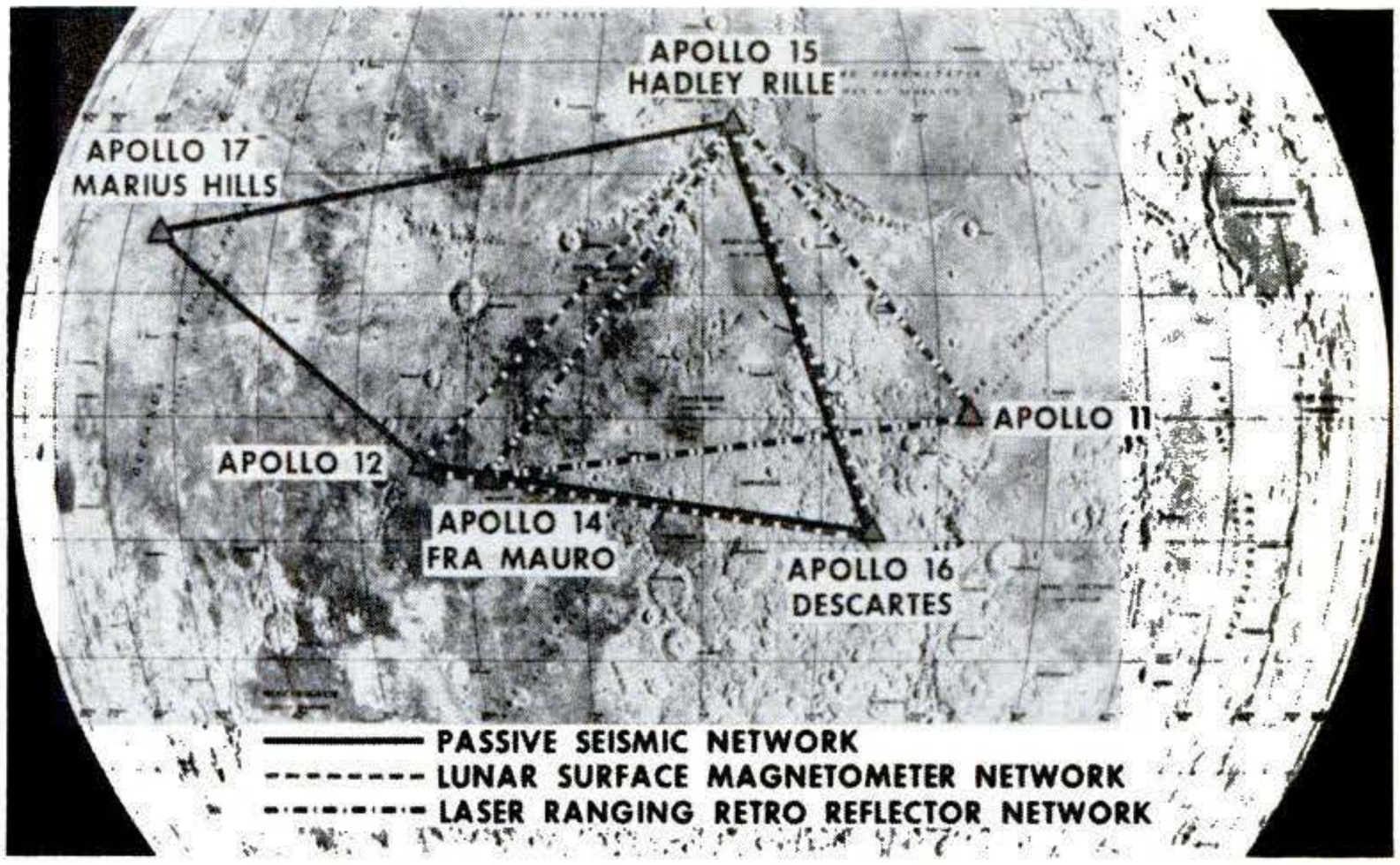
Thus Apollo 15 firmly established that on the moon the same situation exists that we know so well here on Earth: As you descend deeper and deeper into a mine shaft, the temperature increases, because the Earth's interior is hot. On the moon the reason can only be the same, and thus Apollo 15 seems to have settled an old scientific argument between the "cold mooners" and the "hot mooners" in favor of the latter.

Radioactive heating. Preliminary results of the Apollo 15 heat-flow experiment indicate the heat flow from the moon's interior outward is about one-fifth that of Earth. Interestingly enough, this is the figure you would expect if you consider the relative volumes and surface areas of the two bodies, and assume the main source of the outward heat flow is heat produced by a similar mix of radioactive materials such as uranium, thorium, and potassium.

Apollo 15 placed the third ALSEP (*A*pollo *L*unar *S*urface *E*xperiments *P*ackage) on the moon. By September 24, 1971, it had been working well for 55 days. Along with the Apollo 12 ALSEP in the Ocean of Storms (in operation for 674 days) and the Apollo 14 ALSEP at Fra Mauro (in operation for 231 days), the Apollo 15 station has given us a very effective science network on the moon.

Science stations on the moon

Network of stations beaming data to Earth is growing. Moonquakes can be pinpointed using sensors at Apollo 12, 14, and 15 sites; other experiments map distances, record magnetic fields.



All ALSEP stations are equipped with passive seismometers, and the network now permits us not only to determine the location of meteoroid impacts on the lunar surface, but in the case of moonquakes, depth as well.

During the first lunar perigee after deployment of the Apollo 15 ALSEP, a large moonquake occurred and was promptly nailed down by triangulation at approximately 450 miles beneath the surface and 370 miles west of the crater Tycho.

Seismic impulse puzzle. The propagation velocity of the seismic waves through the depths of the moon's body has given scientists new insights into the nature and stratification of the lunar interior. The velocity seems to gradually increase down to a depth of about 15 miles—then there is a sharp increase.

This abrupt increase can only be accounted for by a change to a denser material, possibly the base of a lunar crust formed at an earlier geological age. At a depth of 40 miles, the velocity is estimated to be about six miles per second. Velocities that great do not occur in the earth until depths of some 300 miles!

This discrepancy is all the more remarkable, for under the six-times-

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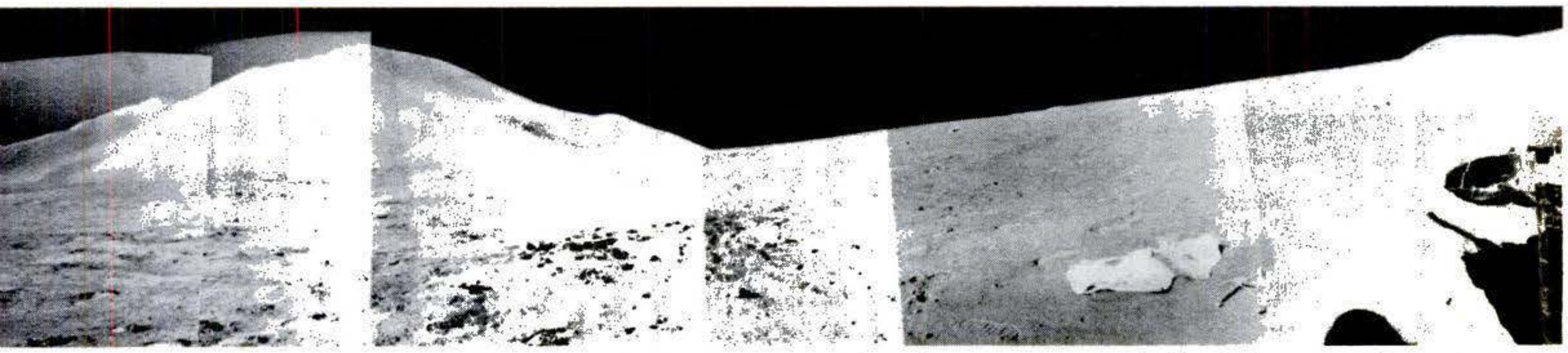

from Mt. Hadley (left) to Mt. Hadley Delta (right). St. George Crater is on right edge of Hadley Delta slope and Hill 305 is far right on horizon. Site is marked with footprints of astronauts who set up the still-operating experiments.

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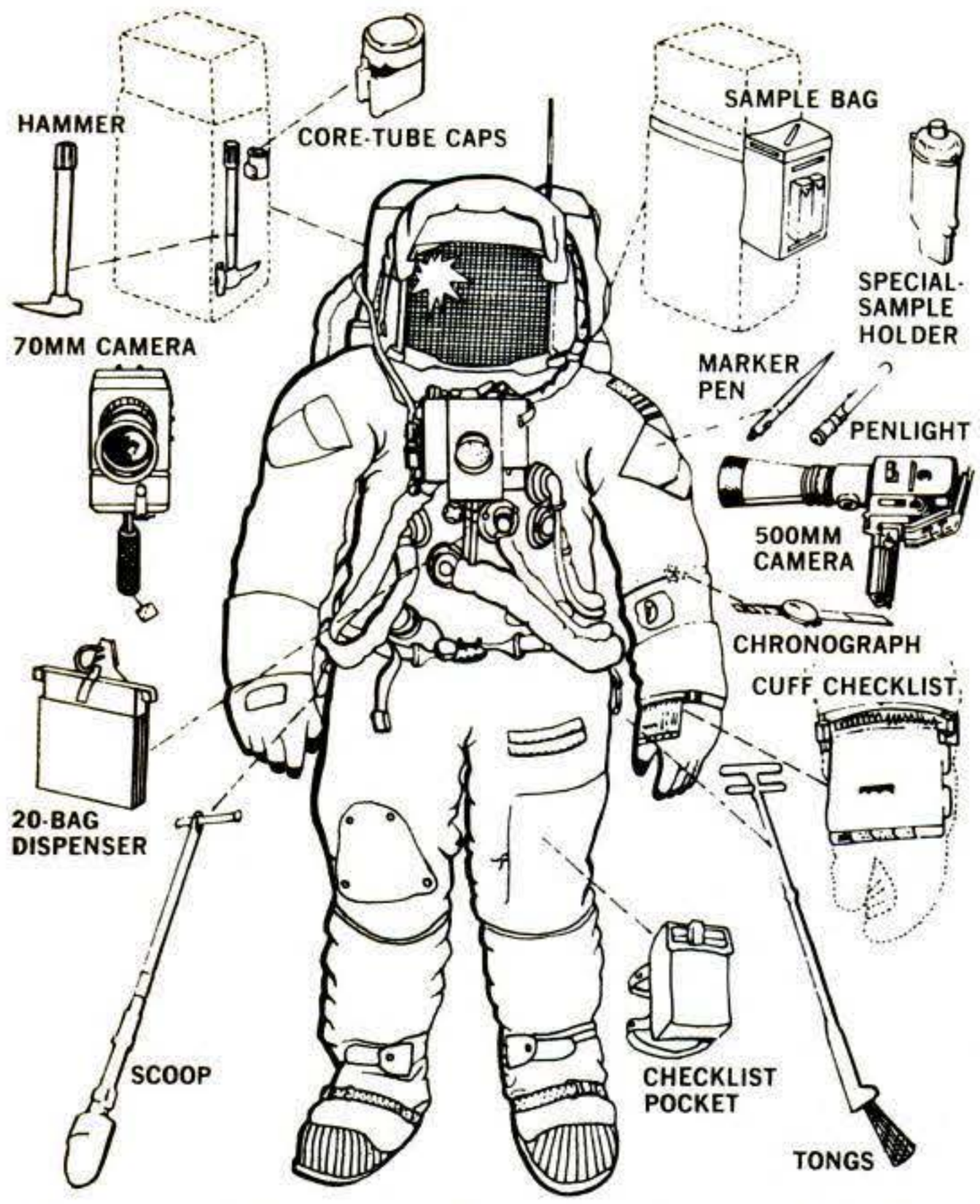

Well-equipped to explore the desolate surface of the moon, Scott is shown at work above (his gear, left). Tongs in his hand simplify picking up samples; bending is difficult in pressurized, bulky spacesuit.

stronger gravity on Earth, the upper layers exert a much greater weight and compacting pressure on the underlying strata. No rocks examined thus far would, under the actual pressures expected at a lunar depth of only 40 miles, transmit seismic impulses at speeds as high as six miles a second. This is just one of many new questions Apollo 15 brought home.

Lunar photography. While Scott and Irwin were exploring the canyon-like Hadley Rille and the foothills of the lunar Apennines on the surface, Command Module Pilot Alfred M. Worden was just as busy in his 74 orbits around the moon. With his mapping camera he produced 3,400 high-resolution photographs of excellent quality.

Of the lunar surface overflown in daylight, magnificent stereoscopic photography was obtained that provides elevation data for mapmakers and useful information for geologists.

The gamma-ray spectrometer in Worden's orbiting CSM clearly identified lunar areas of different radioactivity levels. Mare Imbrium and Oceanus Procellarum showed highest readings, Mare Crisium and Mare Serenitatis somewhat lower, and the highlands, particularly on the moon's far side, the lowest of all.

Survey in orbit. Measurements by X-ray spectrometer showed the lunar eastern highlands two to three times higher in aluminum content than the mare basins, and the lunar far-side highlands even richer in aluminum. Lunar minerals emit telltale secondary radiations from bombardment by solar radiation [PS, Feb. '70].

A rather unexpected discovery was made by Worden's mass spectrometer. It indicated that the amount of gas at his orbital altitude around the moon was about 10 times higher than that recorded on the way back to Earth. Gases detected included water vapor, carbon dioxide, and a variety of hydrocarbons. Worden's laser altimeter showed that, relative to an idealized spherical moon, the average lunar far side is about 6,000 feet high, whereas the average front side is about 6,000 feet low. The moon thus resembles a pear with the stem pointing away from the Earth.

Analysis of all the data, samples, and pictures is underway. But even after everything is sorted out, it will be next to impossible to identify what lunar scientists have learned from Apollo 15 only. Every one of the previous Apollo flights, as well as their unmanned predecessors (Rangers, Surveyors, and Lunar Orbiters) have raised new questions while adding bits and pieces to the jigsaw puzzle of the moon and its history.

We are left with these basic questions: How far has science progressed in assembling the total puzzle? What is the latest scientific opinion on the moon's origin and history? While there is still much disagreement on details, the following story of the sun, the Earth, and the moon seems to find ever-growing acceptance:

Creation from collapse. Our solar system was formed from a primordial cloud of dust and solid debris. Gravitational collapse of the cloud formed the sun, but all cloud particles with tangential speeds high enough to prevent their falling into the sun kept orbiting around it. Mutual gravitational attraction between these orbiting parts gradually aligned them in the plane of ecliptic.

Random accumulation of some heavier parts formed gravitational centers which, after many revolutions around the sun, gradually sucked up the remaining particles like a vacuum cleaner. One product of this accretion was our own planet. All the planets were formed in the same manner. The sole exception is the asteroid belt, where parts in similar orbits thus far have failed to condense into a planet.

Just as the material that formed the planets had too high a tangential speed to fall into the sun, some material attracted by the accreting Earth stayed in orbit around Earth instead. It formed a subgravitational center whose gravitational collapse then produced the moon.

Impact melts parts. Radioactive dating and other methods led scientists to believe the near-simultaneous birth of both the Earth and its moon took place about 4.6 billion years ago. There is reason to believe the newly born moon was much closer to Earth than it is today. The heat produced by impact melted the myriads of impinging parts. The lighter material floated to the surface and soon cooled off through radiation.

The moon's first solid surface, formed about 4.5 billion years ago, was a rock "scum." But impacts from the continuing accretion process continued to pound the hardening crust —shattering it, cratering it, and altering its minerals.

Half a billion years later, the crust had substantially thickened, and only an occasional heavy accretion impact (or shall we now call it a meteoroid?) cracked it here and there. These blows let lava from the hot interior ooze up, filling basins and older craters with basalt-like rock, sometimes several miles thick.

Missing clues to history. Thus the moon today provides us with a museum full of frozen evidence of its earliest history. And since the moon's early history is virtually identical with Earth's, the lunar rocks now bring us unprecedented insights into Earth's early years, of which we knew virtually nothing. For on Earth, continental upheavals, ocean water, river sedimentation, rain, wind, and vegetation have virtually eradicated all fingerprints and clues of the first two-thirds of Earth history.

Mankind depends on the Earth's mineral resources for survival. Who can tell today what eminently practical consequences may one day spring from man's better understanding of Earth's geological history? PS

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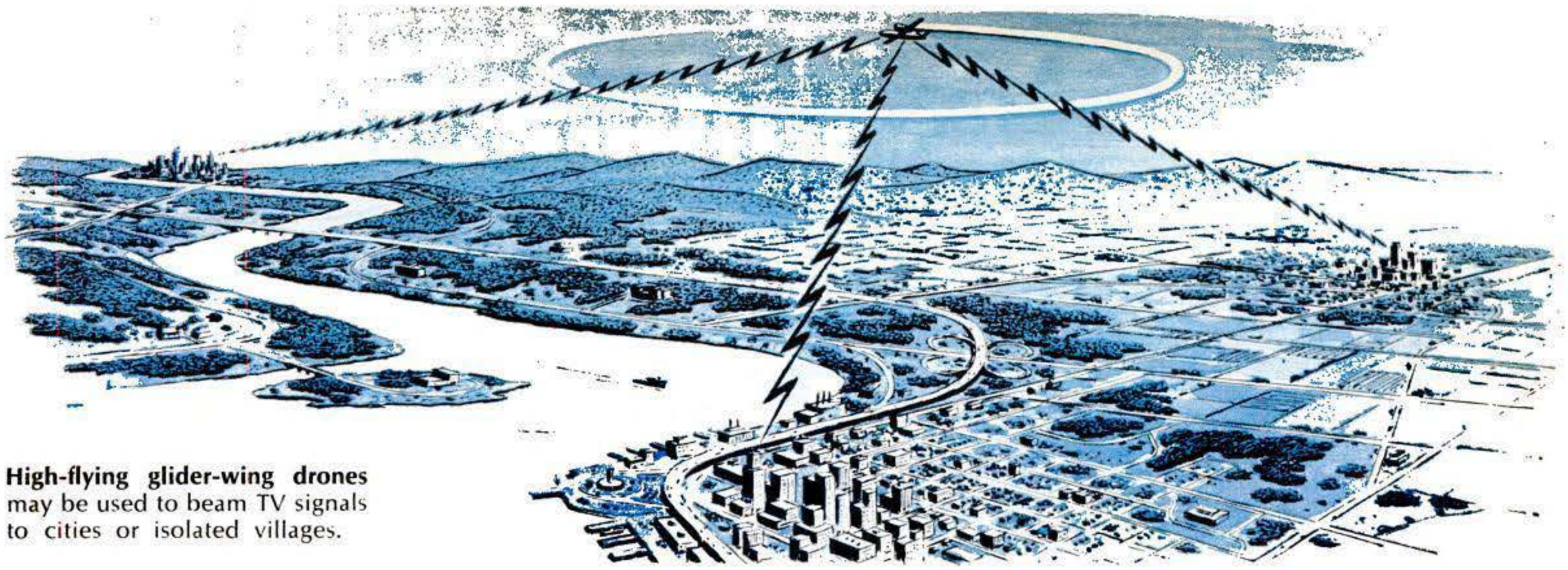


High-flying glider-wing drones may be used to beam TV signals to cities or isolated villages.

You may be a "pilot" in the Wild New World of Drones

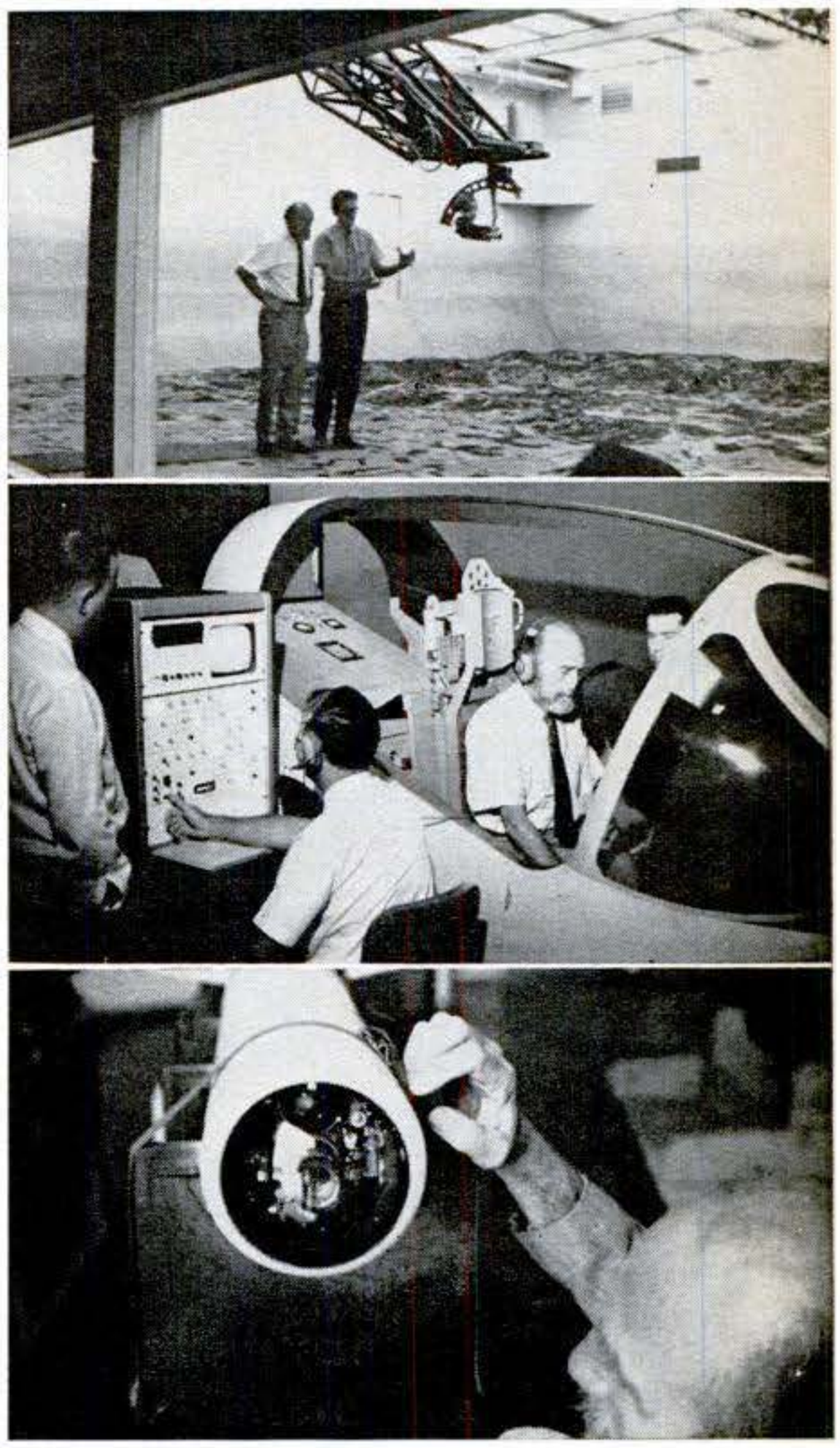
An electronics aerospace revolution is putting fliers in ground-based swivel chairs, taking the hazards from some missions

By **BEN KOCIVAR** / *PS Consulting Editor, Flying*

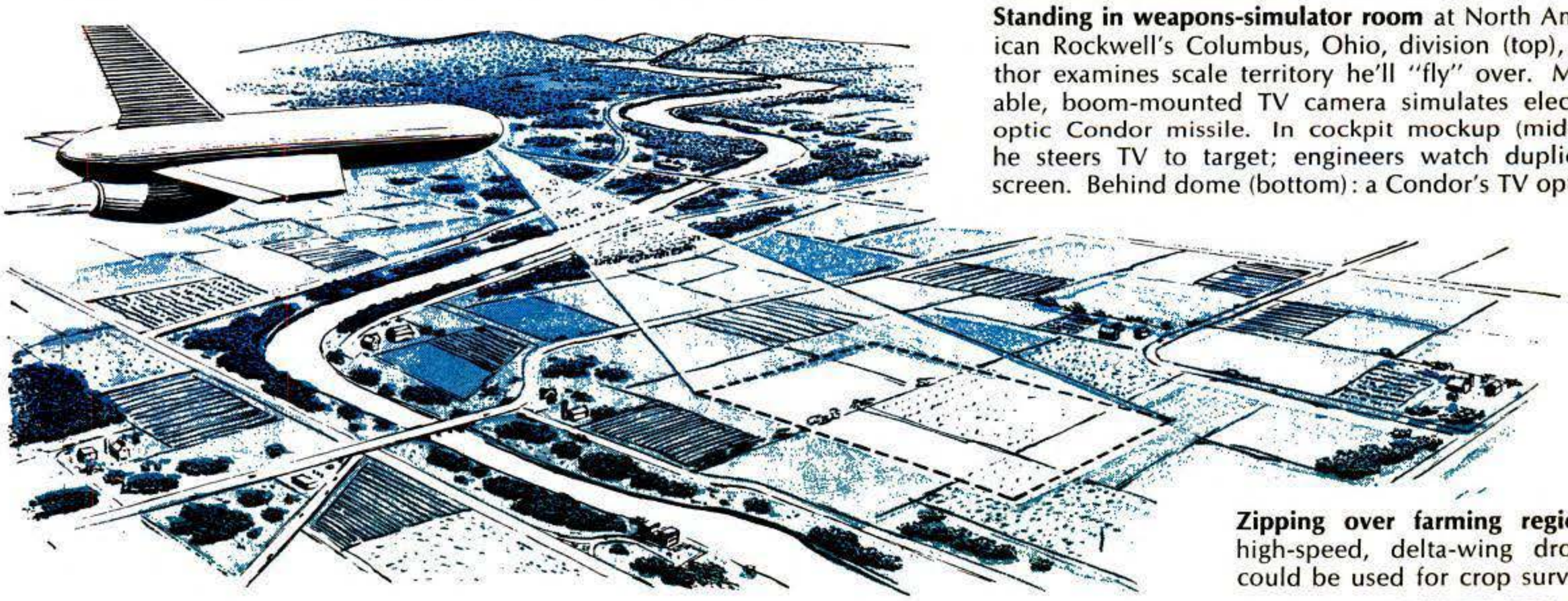
Significant changes in air-war concepts are developing as RPVs (Remotely Piloted Vehicles) are transformed from blueprints into hardware. Remotely piloted drones —already used in Vietnam and other political hotspots— will be confined to military missions for some time, but various nonmilitary RPV spin-offs are possible:

- Educational-TV relay vehicles for remote areas.
- Hurricane watches and investigation.
- Crop surveillance using infrared film and other sensors.
- Coastal and iceberg patrol by the Coast Guard.
- Border patrol and traffic surveillance.

While surveying the RPV military scene recently, I climbed into the bomber-navigator "seat" of *Continued*



Standing in weapons-simulator room at North American Rockwell's Columbus, Ohio, division (top), author examines scale territory he'll "fly" over. Movable, boom-mounted TV camera simulates electro-optic Condor missile. In cockpit mockup (middle) he steers TV to target; engineers watch duplicate screen. Behind dome (bottom): a Condor's TV optics.



Zipping over farming regions, high-speed, delta-wing drones could be used for crop surveys.

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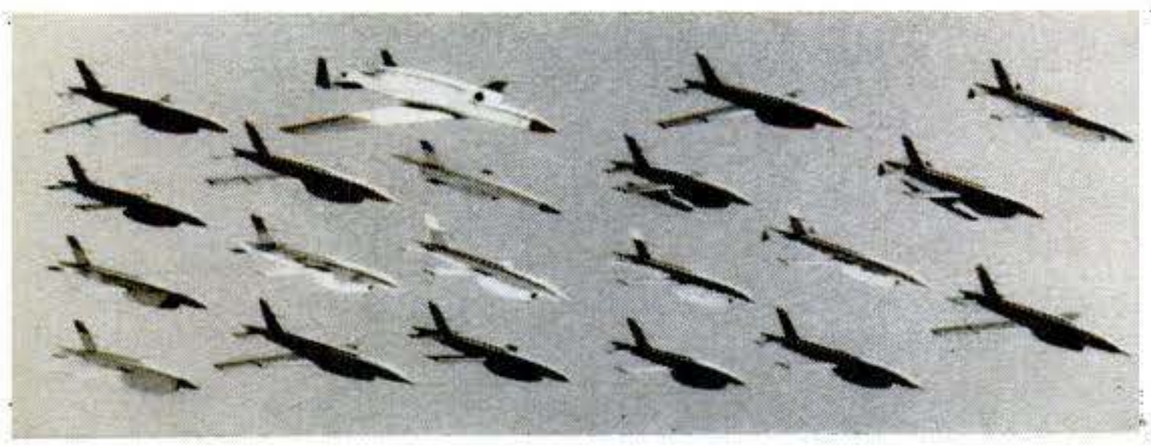
a Grumman A-6 Navy jet. After 15 minutes of instruction I guided a rocket-powered Condor missile for a direct hit on a SAM missile site's radar control center.

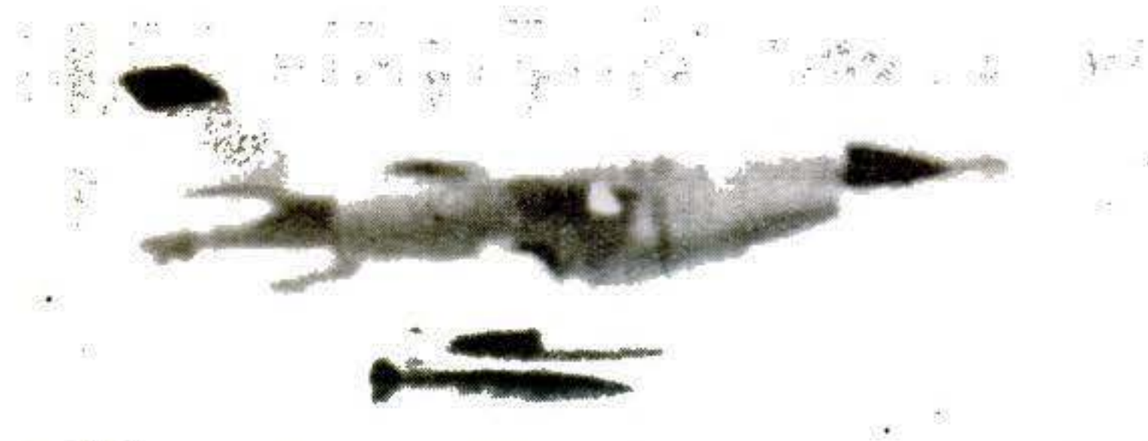
Launch point was about 25 miles away from "target." With a stubby fighter-control stick and other cockpit controls, I steered the missile using a TV picture transmitted from its nose to a small-screen cockpit scope. Switching back and forth from wide-angle to telephoto image, I guided the bird by direct control, then locked on target for automatic flight when I became sure of my aim. Meanwhile, my Grumman jet was "flying" evasively away from the hot target area at 600 mph.

As you've probably gathered, I was "flying" in a simulator. Although the TV airplane was over a three-dimensional scale model of a 40-by-80-mile piece of "enemy" territory, I knew an actual Condor weapons system exists—one of several TV-guided missiles in use or under development by the armed services. Other U.S. RPVs are in use throughout the world.

Electronic and photo surveillance. It's no secret to the Russians, Chinese, or Arabs, for example, that American-made unmanned drone aircraft have been used for daring penetration missions deep into foreign territory for electronic and photo reconnaissance. This has gone on for years, and the Chinese have shot some down to prove it. Peking showed three Lockheed U-2s and three Ryan Firebee drones reportedly shot down over mainland China. Airborne electronic snooping from outside Russian-Chinese borders and satellite sensors may have replaced overflights now.



Family of Firebee aerial targets and drone systems can be used for wide range of missions by altering the basic configuration.



Bombs away: Two inert, 500-pound bombs are released at test range by pilot "flying" this Firebee from ground-control station.

Special-mission versions of Beechcraft Bonanza 36 can be flown as a manned aircraft, as a pilotless drone, or in combination.

Use of RPVs for airborne surveillance of the touchy Middle East has been considered, tested, and may even be in operation. If adapted to the Suez Canal zone, the drones could relay views to a ground station in Tel Aviv. Israeli military could tape the views and compare them with previously known activity.

Drones for such missions, built by Teledyne Ryan Aeronautical Corp., were tested in California under computer control as they beamed TV pictures to ground stations. The drones can use low-light-level TV cameras [PS, Nov. '70] to detect troop movements at night. Real-time TV pictures can be transmitted anywhere with the CBS Laboratories electronics system.

Thousands of drones controlled from the ground and air have been flown for target practice. Now military planners are using RPVs for missions too risky for human pilots. There have been hundreds and possibly thousands of drone missions in Vietnam. At one point a "recce" (reconnaissance) drone sent over North Vietnam brought back damage photos of a bridge that had cost two manned aircraft in other attempts.

It's also no secret that a pilotless Teledyne Ryan Firebee drone has engaged an F-4 McDonnell Douglas Phantom Mach II jet in a practice dogfight and evaded our hottest fighter.

More for our tax dollars? Many experts question giving up fighters and bombers that cost five to 50 million dollars per copy. But North American engineers estimate that for the cost of one F-15 Air Superiority fighter, Uncle Sam could get 32 mixed versions of RPVs to do comparable missions. RPV cost: $150,000 to $300,000 each.

What is new about automatically flown airplanes, drones, or missiles? For years, pilotless drones have been controlled using speed, altitude, and heading data telemetered back to the ground controller, or tracked by radar. The new recently added element is *real-time control.* Now a "pilot" on the ground can actually see out from a drone while it's 50 miles away. Relay planes and satellites may extend this distance to hundreds of miles or more. TV puts the pilot's eyes "on board" the aircraft and telephoto lenses often let him see more than if he were physically there. The data-link transmission of control signals is jamproof from countermeasures.

Tomorrow's Air Force pilots, at no personal risk, will be able to fly supersonic fighters hundreds of miles into enemy territory, drop bombs from high or low altitudes, intercept enemy fighters, trigger off deadly SAM rockets, and fly sneaky reconnaissance missions into the most heavily defended areas.

To fly the missions, you will not have to be a 20-20-vision superhuman, but you will have to be bright and quick. You may work from a swivel chair in an air-conditioned underground command post hundreds of miles away, or airborne 15 miles up.

What will drones look like? With no pilot to accommodate, a completely new-looking plane becomes possible. Drones don't need life-support systems like oxygen, nor heavy armor plating. Components need not be man-rated for reliability and will be much cheaper. Many RPVs will be designed for single or limited missions, and new designs may include aluminum-covered foam, glass fiber, cardboard, and other low-cost materials. New short-life jet engines will cost less.

The Air Force is running a design competition among leading airplane and avionics manufacturers for four RPV vehicles: air-to-air, air-to-ground, reconnaissance, and a multipurpose craft to perform all three missions.

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away. TV puts the pilot "on board"

The Army and Navy are also examining new uses for RPVs. In general, the needs seem to be in the direction of low-cost, low-altitude operations.

Without a cockpit with its bulges for windshields, ejection seats, and environmental protection, the fuselage—if there is one—will be more streamlined. The craft will be more maneuverable and capable of pulling 12-g loads—more than most pilots can tolerate and still function. Tighter turns for dogfights and evasive maneuvers to evade enemy missiles will be possible.

Moving into enemy territory. RPVs will be able to fly in formation, simulating waves of attacking aircraft, under control of a single pilot on the ground or in an airborne station. RPVs may be controlled by relays of specialists in fighting, bombing, and landing.

Future drones may not all be fixed-wing aircraft. A number of rotary-wing drones are already in service for antisub work. In Germany, the famed Dornier aircraft company has been developing a tethered-rotor platform for communication and surveillance, and the Aerodyne, which promises to combine high speed with vertical-takeoff-and-landing (VTOL) capability.

The Aerodyne principle was started in the U.S. by Alexander Lippisch, who also created the first delta-wing rocket plane. The Aerodyne has no wings. Lift is produced in high-speed flight by deflecting the air jet from the inner duct surrounding a prop-type fan. For hovering, the jet is deflected far enough to produce lift at an attack angle of 20 to 30 degrees. A relatively weak turbojet exhaust at the end of the tail boom controls the yaw and pitch axes.

There are several experimental "quieted" observation vehicles for sneaky reconnaissance work. These could be used for FAC (forward air control) and SCAR (strike control and reconnaissance) in extremely dangerous areas.

So we're now seeing drones that fly from ground level to over 90,000 feet, from glider-like silent flight to lightning bursts at projected speeds of Mach 4.

New names in drone industry. Veteran names in drones are Teledyne Ryan, Northrop, and Beech. Last October the Air Force awarded two study concepts on RPVs to Teledyne Ryan and Northrop. The contracts, just over one-half million dollars, are small by military order standards, but much larger orders are coming. Ten companies bid for this job, and they'll be pitching for parts of the program when the bidding starts. These are: General Dynamics, Cornell Aeronautical Lab, Westinghouse Electric, Lockheed, Grumman Aerospace, Hughes Aircraft, North American Rockwell, and McDonnell Douglas Aircraft Corp.

Already over 100,000 drones have been built and flown, mostly by Teledyne Ryan, Beech, and Northrop. Electronics for control, guidance, and operation may account for 70 percent of a drone's cost. So it's understandable that companies like RCA, TRW, Cubic Corp., Sperry Rand, Lear Siegler, and Bell Aerosystems are also involved with the hardware.

Some RPVs currently in use were initially built as pilotless vehicles. Others, like modified Model-36 Beech Bonanzas, were changed to QU-22B operational-intelligence-gathering drones for long hours of patrol over Vietnam. A man might be aboard to monitor electronic equipment, but he is not needed to fly the plane.

Basic models of the Teledyne Ryan Firebee have many wing and engine modifications, depending on whether they're meant for short or long missions, high or low altitudes. They can be ground-launched with the help of

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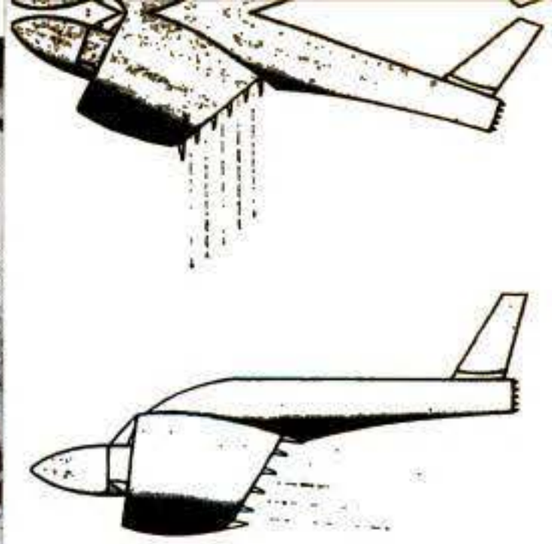
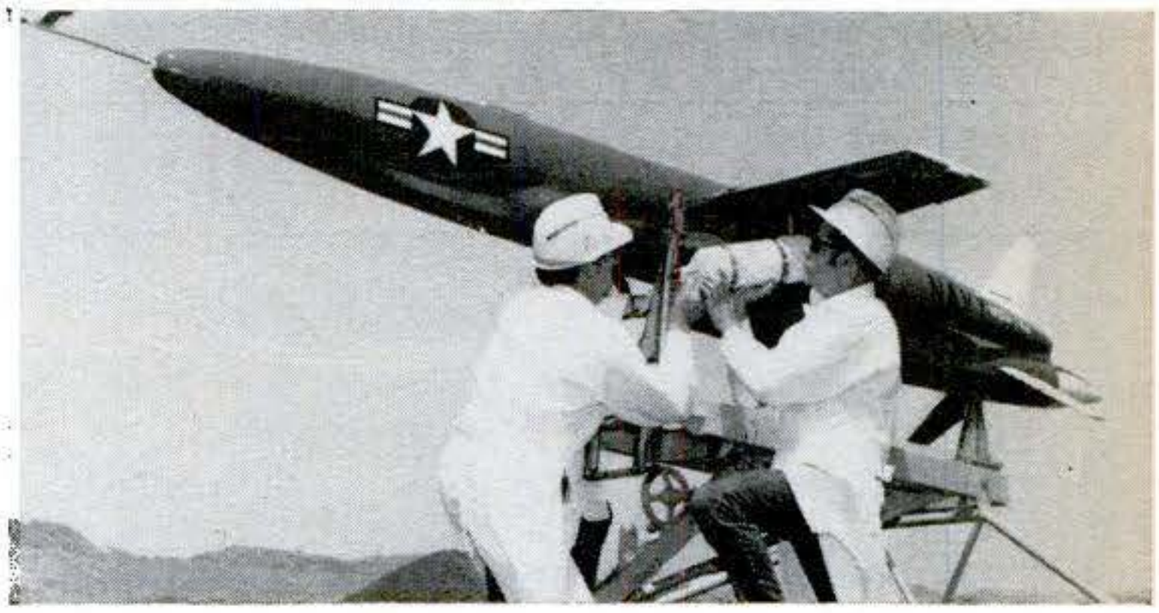
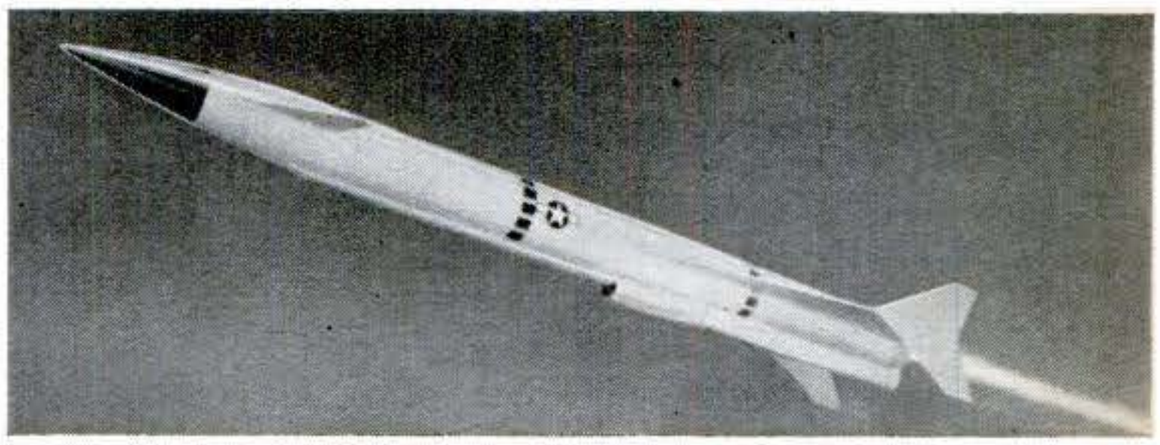


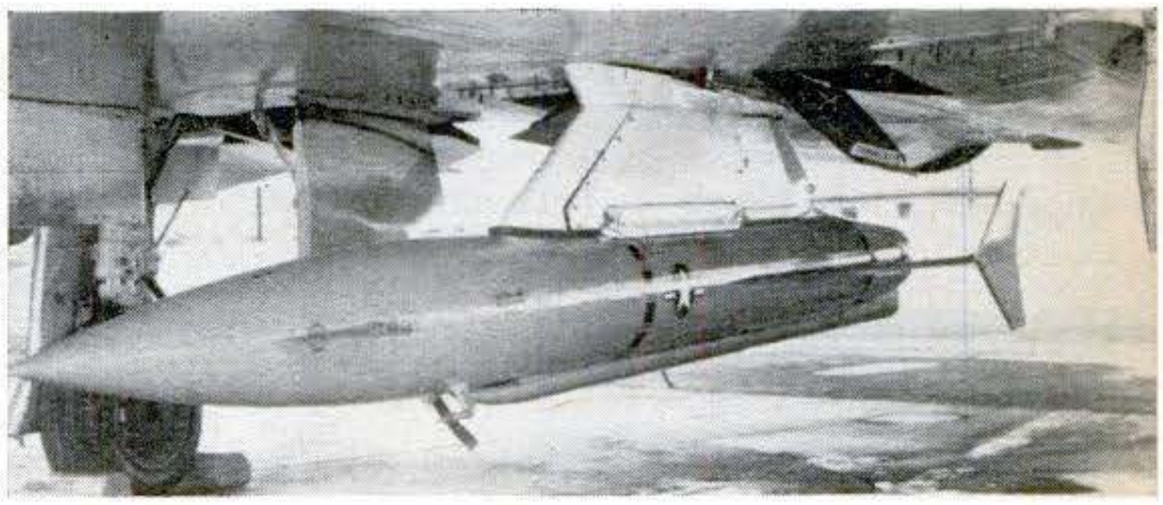
Deflected air jet develops lift in Dornier's wingless Aerodyne, undergoing test in photo. Drawings show body positions for hovering flight (30-degree attack angle, top) and level flight. Aerodyne was designed by creator of delta-wing rocket aircraft.



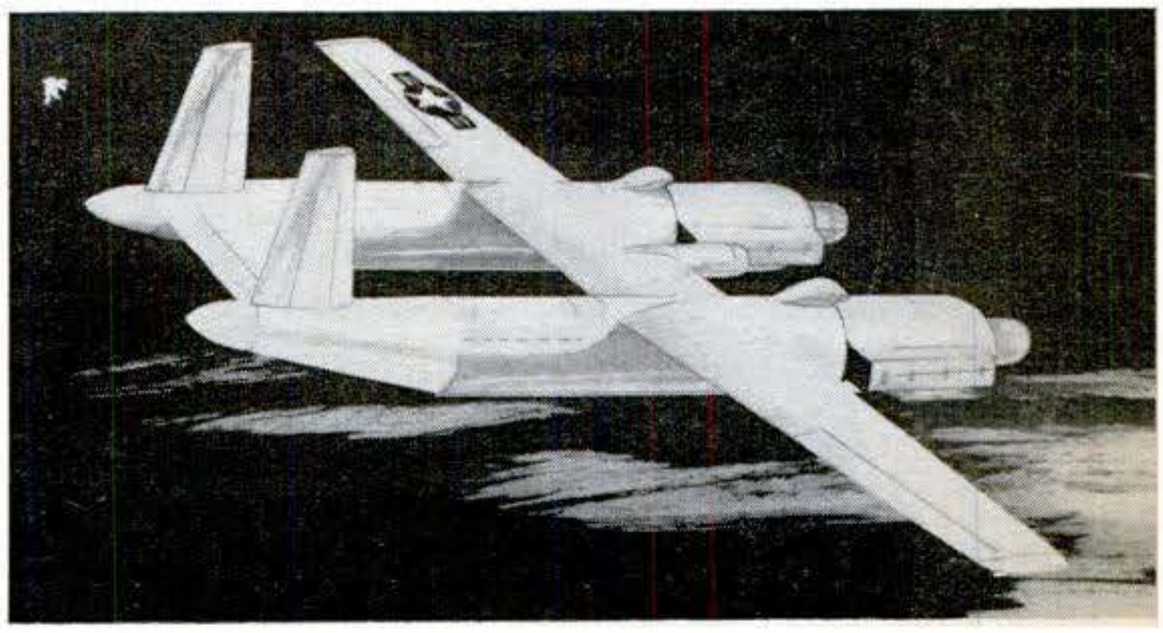
Dropaway rocket pods installed on Northrop target drone make zero launch possible. This eliminates need for airport runway.



High-altitude supersonic missile under development at Beech will operate at 100,000 feet, topping other drones in speed.



Shown beneath F-4C, Beech's Sandpiper demonstrated feasibility of hybrid rocket engine that uses both solid and liquid fuel.



Proposed TV-guided propellered RPV by Beech looks like unmanned version of Lockheed P-38 long-range fighter/bomber.

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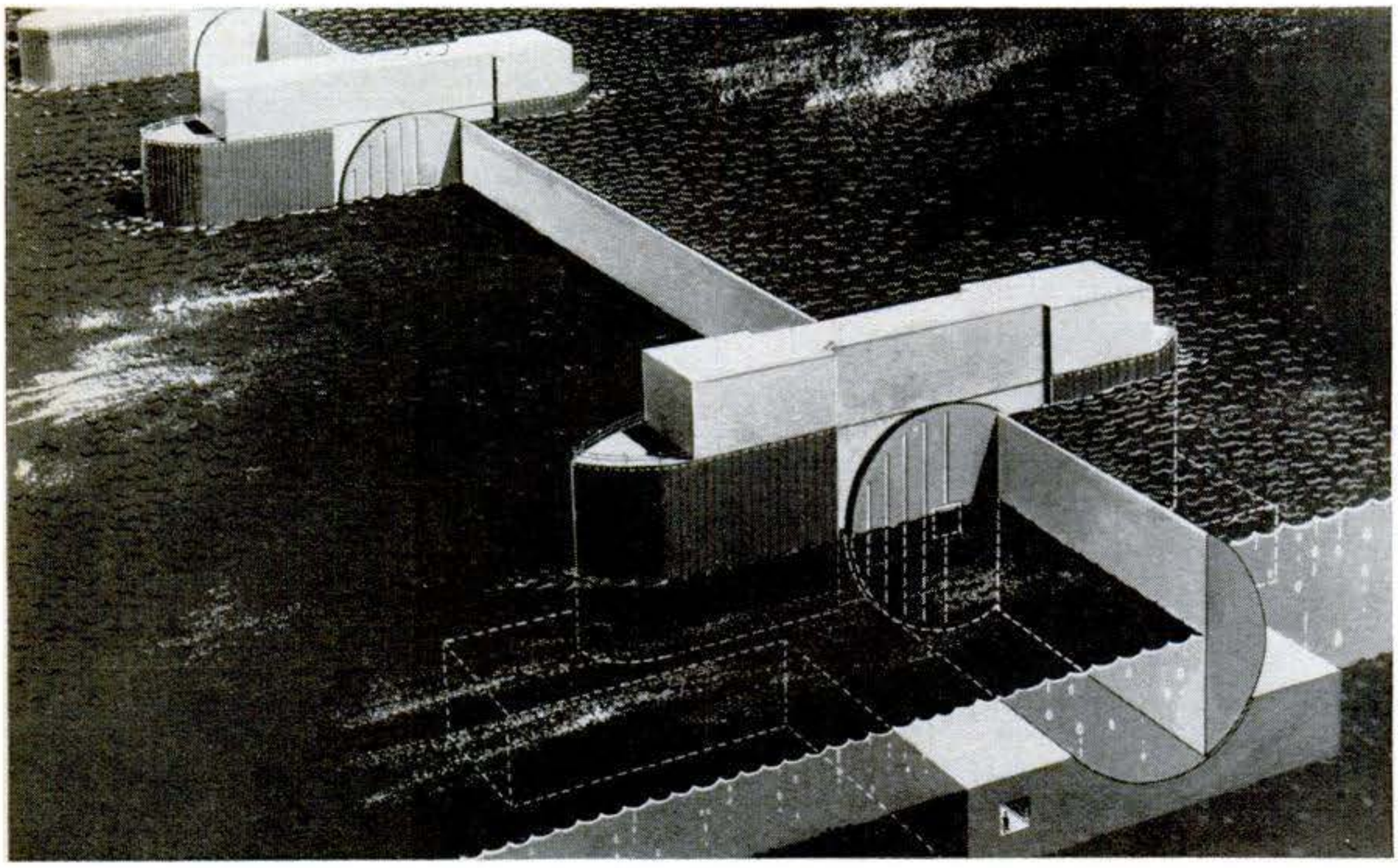
What's New

A PICTURE ROUNDUP OF NEW PRODUCTS AND DEVELOPMENTS



Rotary dam to protect London against floods

This rotary barrier across the Thames River will give London quick protection against tidal flooding. Spanning 1,800 feet, the barrier has sector gates like steel cylinders with three-quarters of their outer shell cut away. With the flat surfaces flush with the river bed—normal position—the 60-foot-high gates will be able to rotate 90 degrees in 15 minutes by electrohydraulic jacks, or by hand pumps if the power fails. Twelve spans, the widest 200 feet, will provide a movable dam above the high-tide level. When they're lowered, ships will be able to use the full depth of the river.

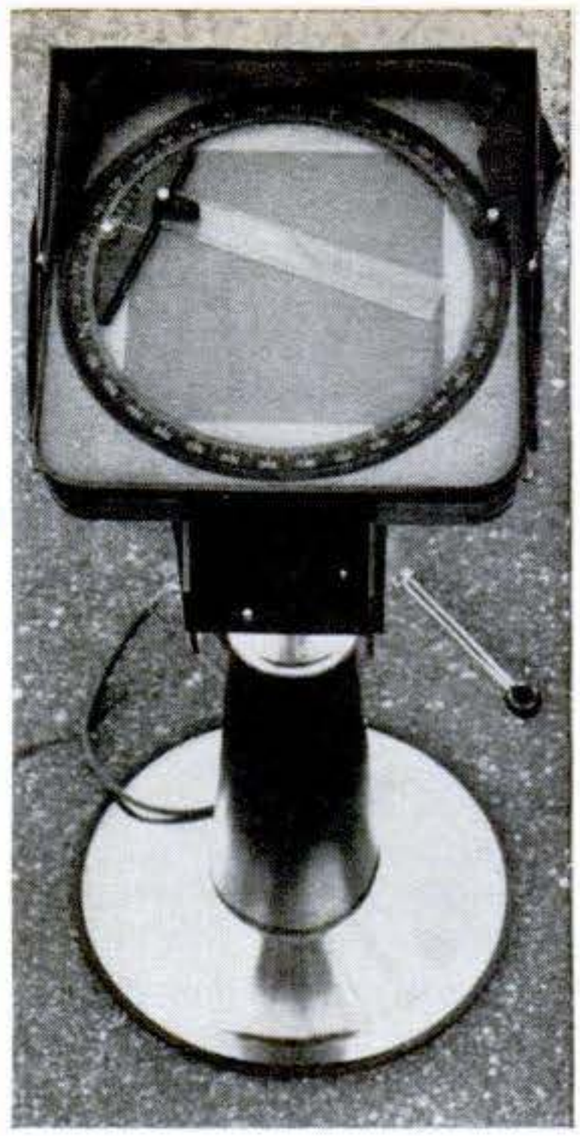
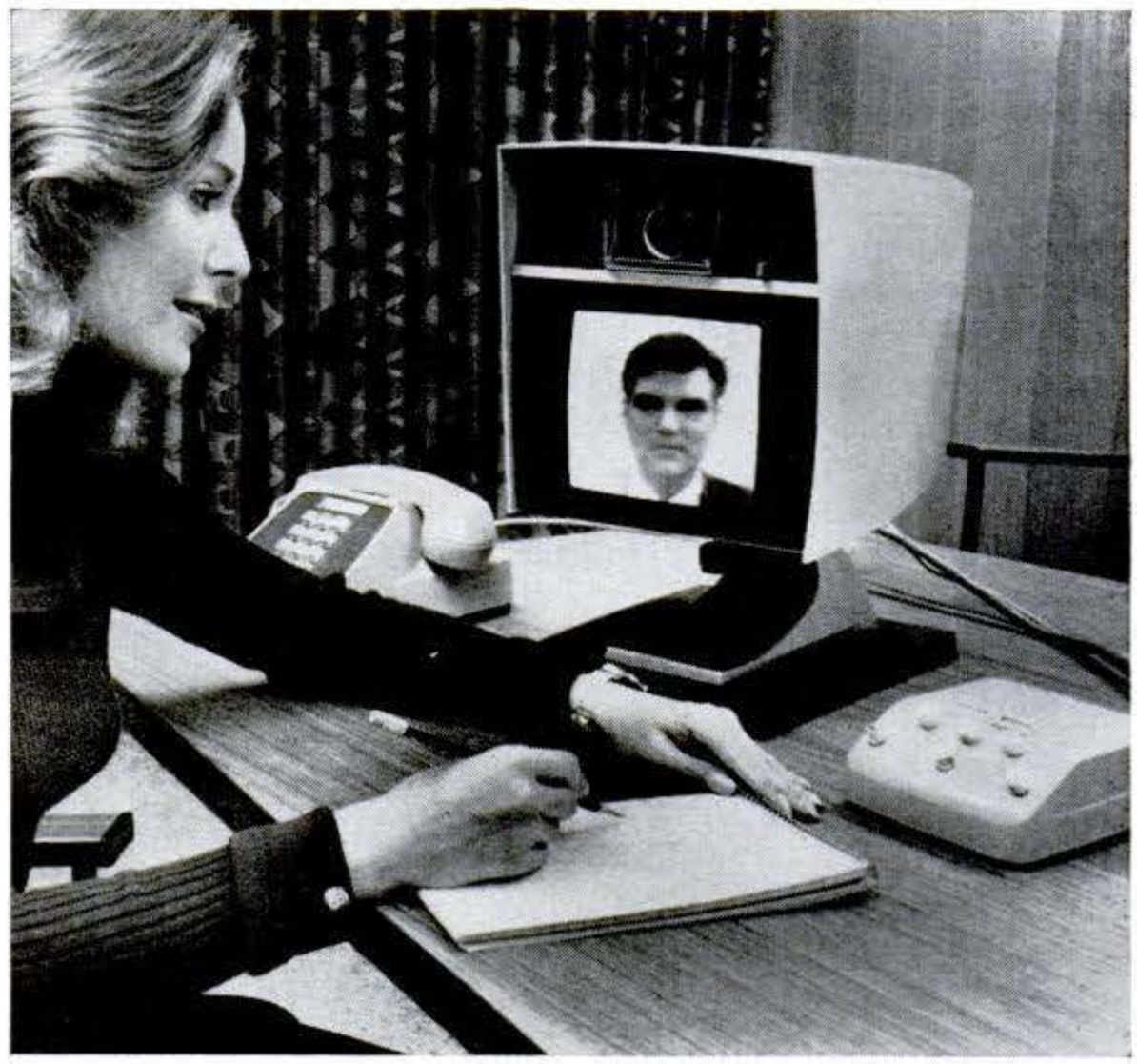


Chart projector

No cumbersome nautical navigation charts with the Micronavigator—it uses small color slides to flash big maps on the screen. Price: $595. A slide with five or six charts on it is $7.50-$10. ADO Corp., 67 Water Witch Ave., Highlands, N.J. 07732.

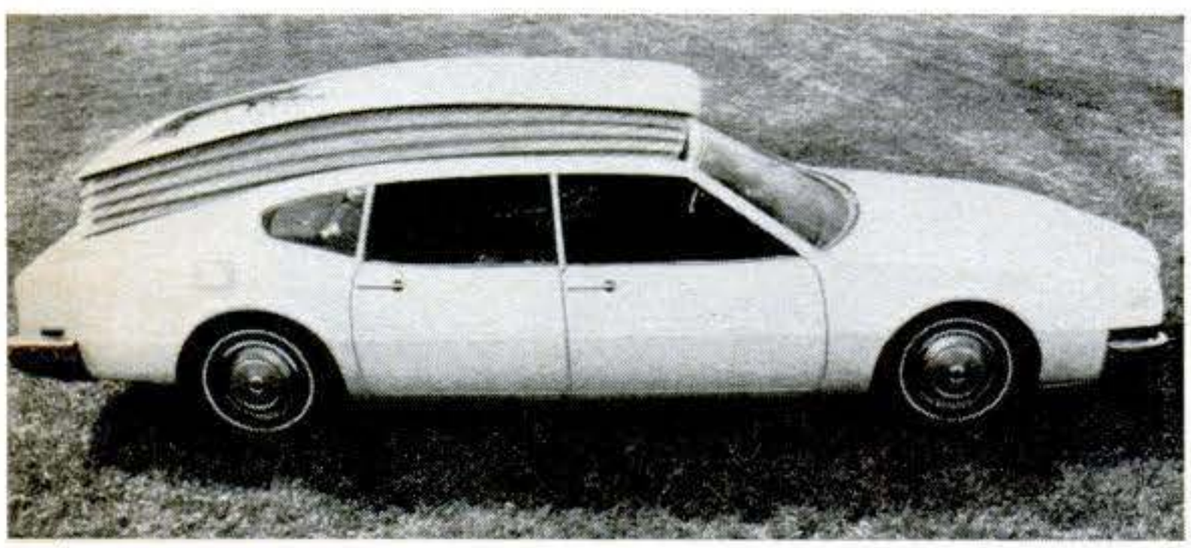
Unlosable golf ball

Crying over lost golf balls? Weep no more. Now there's Bleeper—a golf ball that sends out radio signals to a special pocket receiver, or to an ordinary transistor radio. The signal varies in pitch for different balls. From Euronics Ltd., 24 Beechgrove Ave., Eskbank, Midlothian, Scotland.



Picture phone

Designed to rest on a desk or table, this new experimental video-telephone set from GTE weighs 35 pounds and sits on a 14-inch aluminum pedestal. A special button allows the user to view the other party or to see himself via the camera in his own set. The set also has a zoom control.



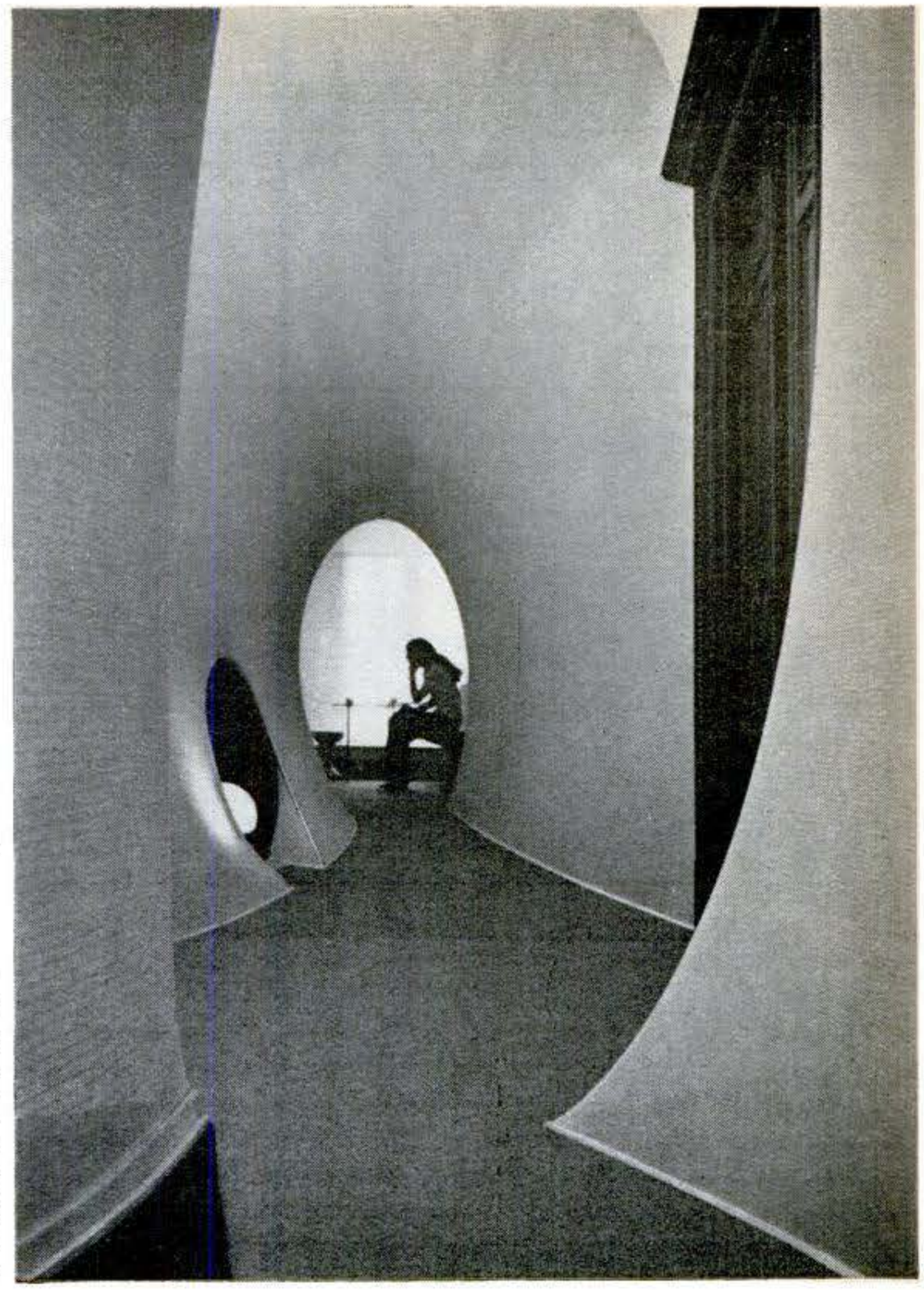
Bellows car

You're looking at Exemplar II, an experimental car with seats that convert to beds, and a roof that extends upward, using electro-hydraulic power, for more headroom. The idea car is from the Copper Development Assn.

Copyrighted material

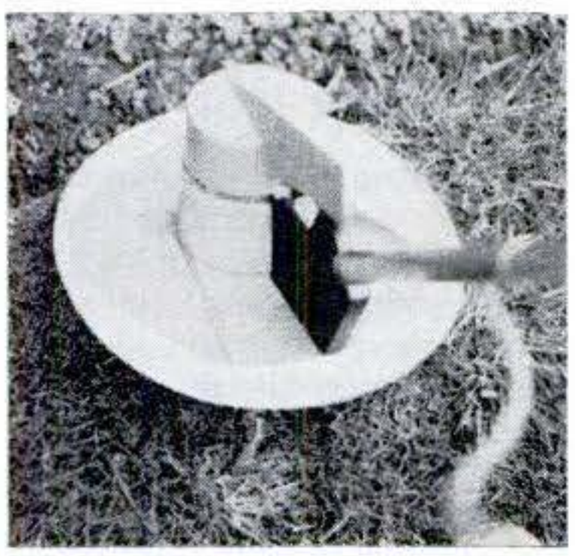
Triple-duty glasses

Telescope, magnifier, and sunglasses all in one—that's what you get with Tele-Specs. The two telescopic lenses are in the earpieces; the larger one can be used as a magnifier. Made for men and women, they're $12.95 from Chris-Craft Marine Accessories, Algonac, Mich. 48001.



Stretch walls

A dwelling of the future? Could be. New York artist Aleksandra Kasuba used see-through stretch nylon shaped into segments of circles to form interior enclosures. The fabric permits a generous air flow, diffuses light, and absorbs sound.



Bladeless mower

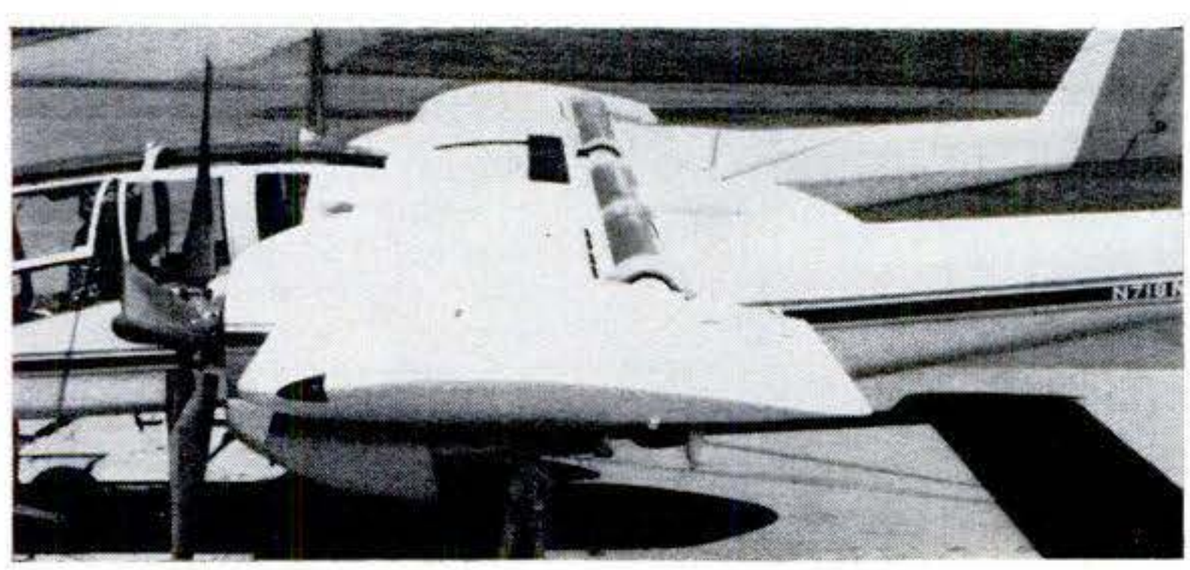
A flailing nylon cord in this German grass cutter eliminates blades. The cord is spun at 12,000 rpm by an electric motor. As it wears, new lengths are pulled from a replaceable cassette. The Adlus UFO is by Max Langenstein KG, 7918 Illertissen, Postfach 108, West Germany.

Battery-drain alarm

Forget to turn off your parking lights? With this alarm you'll remember. Wired to ignition switch and to any accessories desired, it buzzes when you forget to turn something off after you've stopped the engine. It's made by Henri Raufer, Meilen, Zurichsee, Switzerland.

Tilting trailer

How do you pull a 10-foot-wide catamaran over the road when highway laws limit trailer width to eight feet? Use a tilting trailer, that's how. This one is made for a Tornado racer. Trailer-maker Neal Harvey, Cabrillo Beach Yacht Club, San Pedro, Calif., originated the idea.



Rotary-flap plane

Mounted forward of a Bronco's wing flaps, these cylinders, rotated in the direction of air flow, cause the air to cling to the wing and flap, markedly increasing lift. They're being studied by NASA for possible use on STOL—short takeoff and landing—aircraft.

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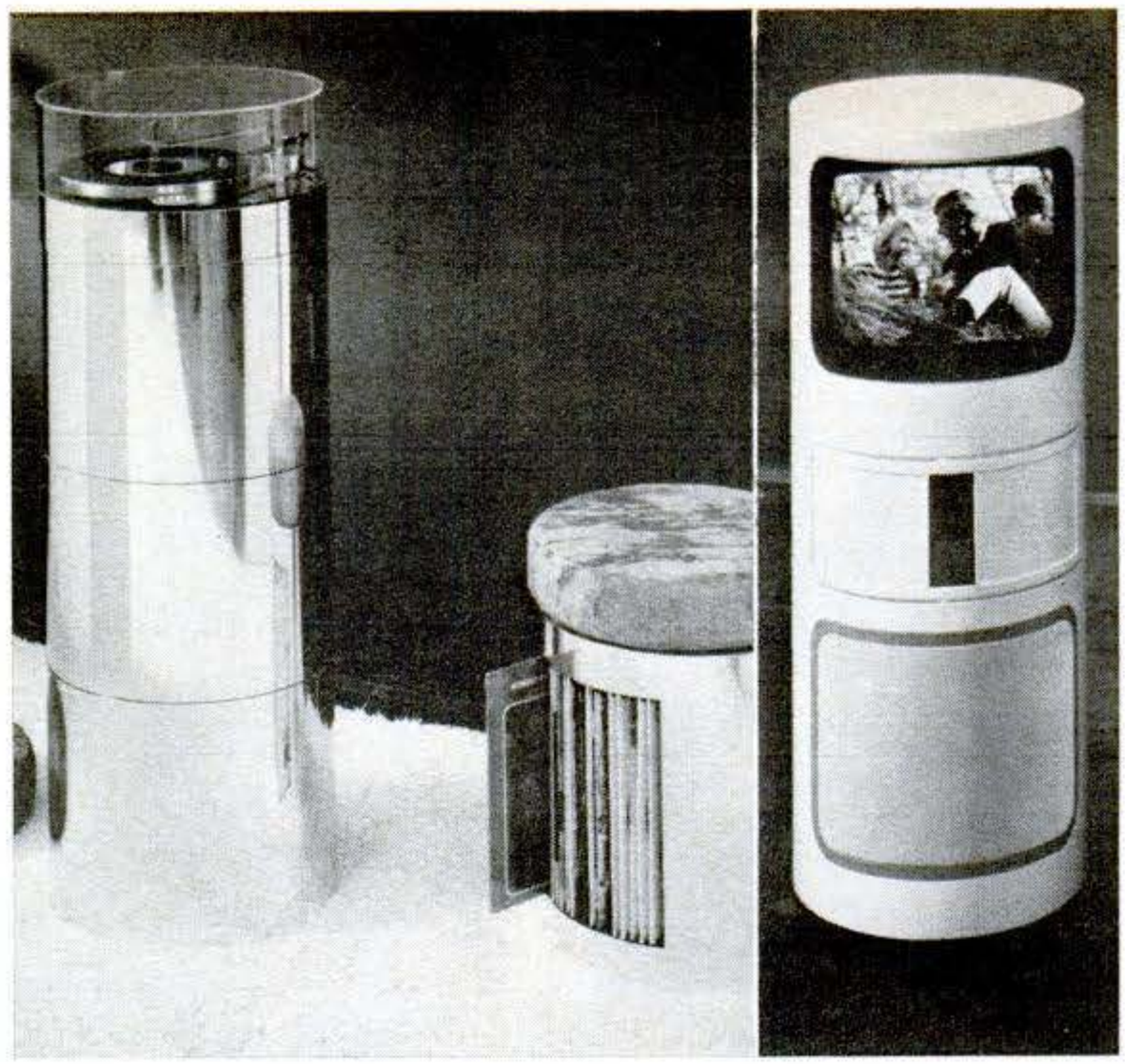
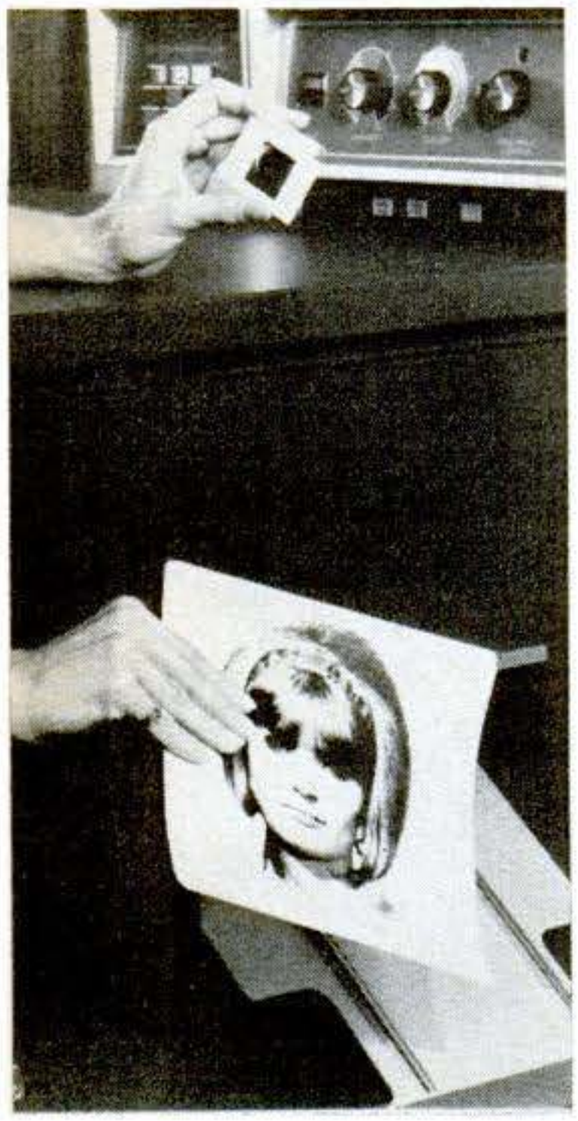
What's New



Music in the round

Bold design and polished cylinders highlight RCA's Audio Totem Pole (far left)—a possible design of the future. The prototype includes FM/AM stereo radio, cassette recorder/player, and record player. A cylinder near it holds records. At near left is a cylindrical TV.

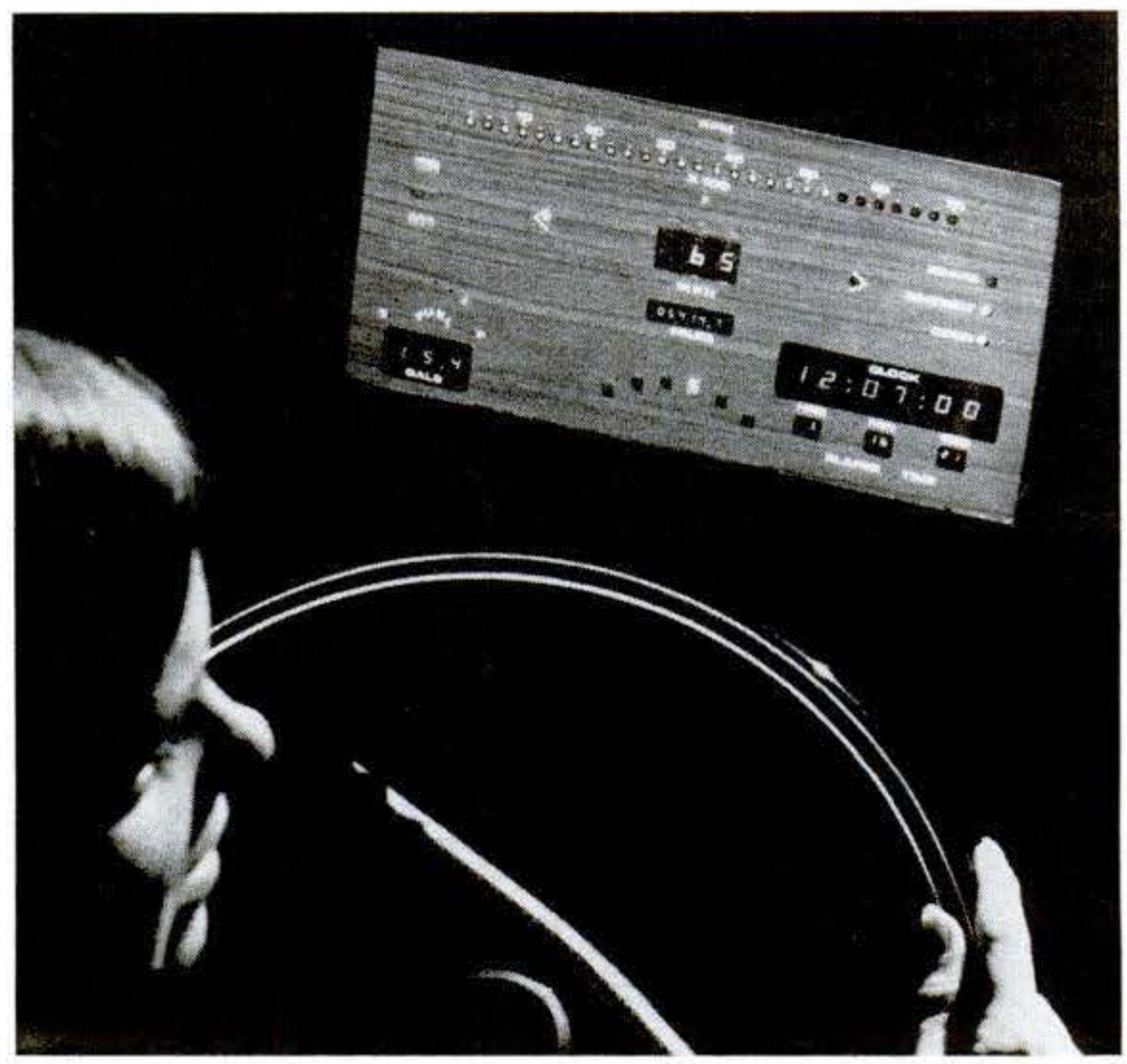


Slide printer

Color enlargements from slides in 30 seconds—that's what this 3M Color-in-Color system produces. It uses 8-, 16-, 35-, or 45mm positive transparencies to turn out five-times enlargements. The system is designed for advertising and other commercial use.

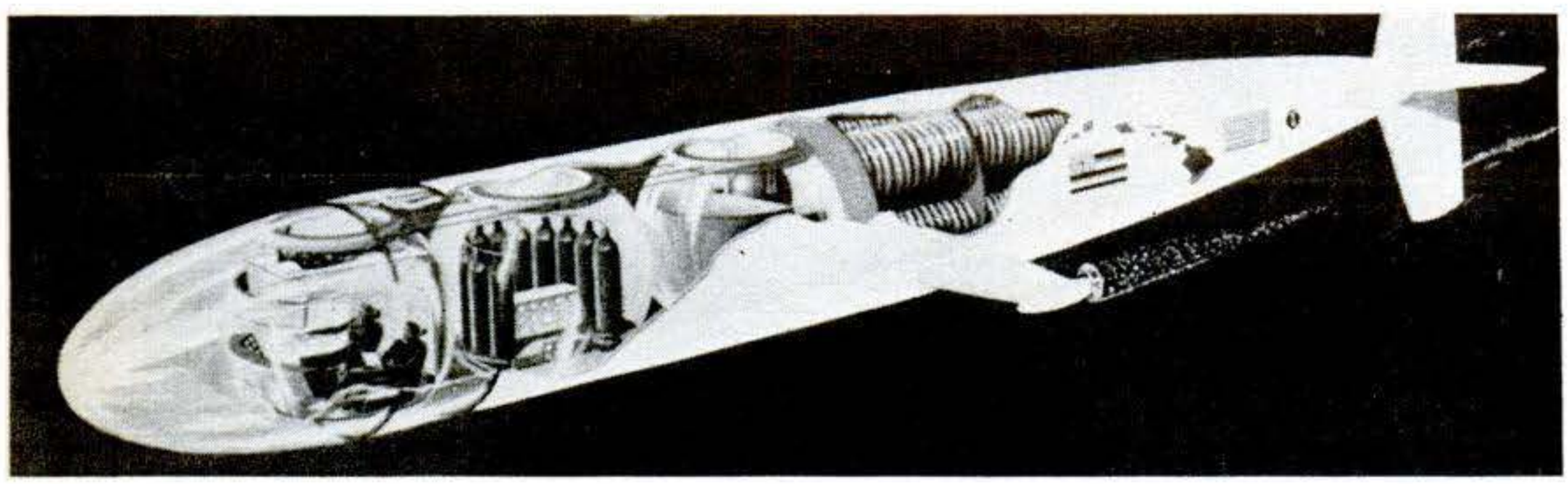
Elliptoid cottage

Put four plywood modules together and you have this three-room house, which sells for about the price of a small house trailer. It comes with built-in wiring and plumbing, and rests on steel legs. The maker is Spherical Housing Systems, Calgary, Alta., Canada.



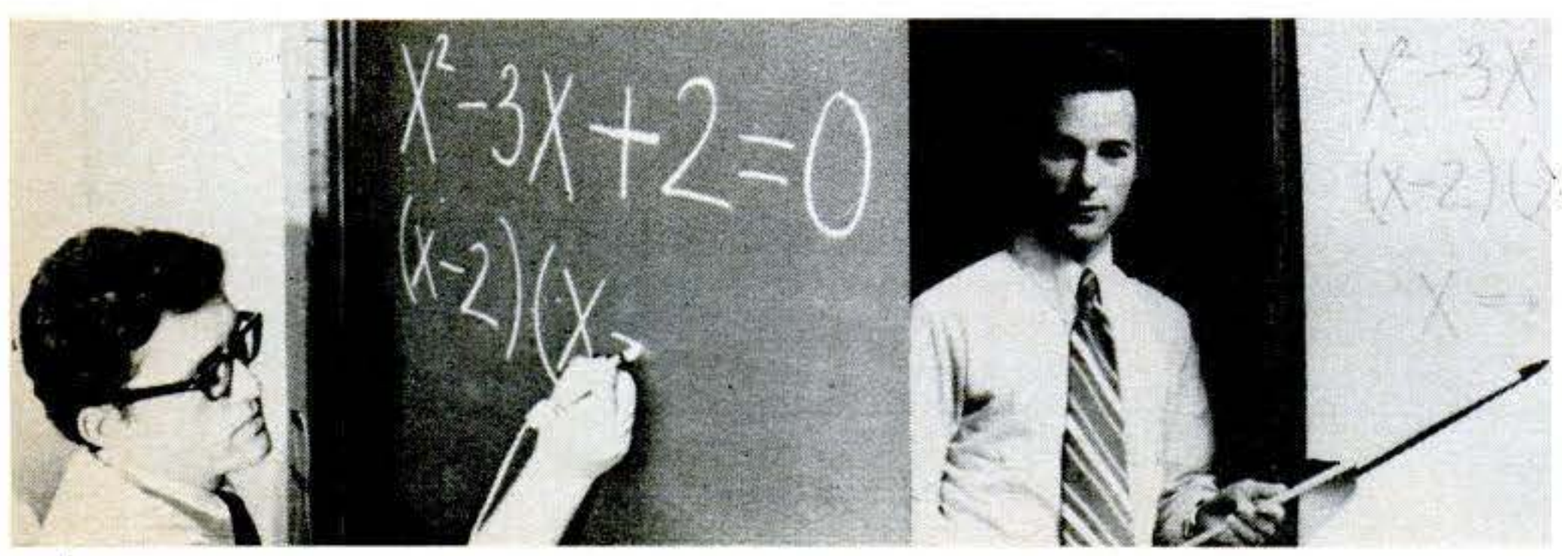
Read-out dashboard

Is this the dashboard of the future? Some 1,500 light-emitting diodes in this Monsanto model give the driver a readout on speed, engine rpm, fuel remaining, time and elapsed time, and the state of his seat belts, doors, and hand brake.



Undersea glider

There's no motor in this sub design by Willis Forman of Hawaii's Oceanic Institute. It's intended to glide, stub wings and tail guiding it forward as it sinks. At the sea bottom, the pilot converts part of a hydrazine supply to hydrogen, and the bubble supplies lift for an upward glide.



Remote blackboard

Almost as fast as an equation is written on one blackboard, it appears on another in this Bell Labs experimental system. The system makes it possible to transmit handwritten information over ordinary telephone lines by encoding it into ultrasonic pulses.

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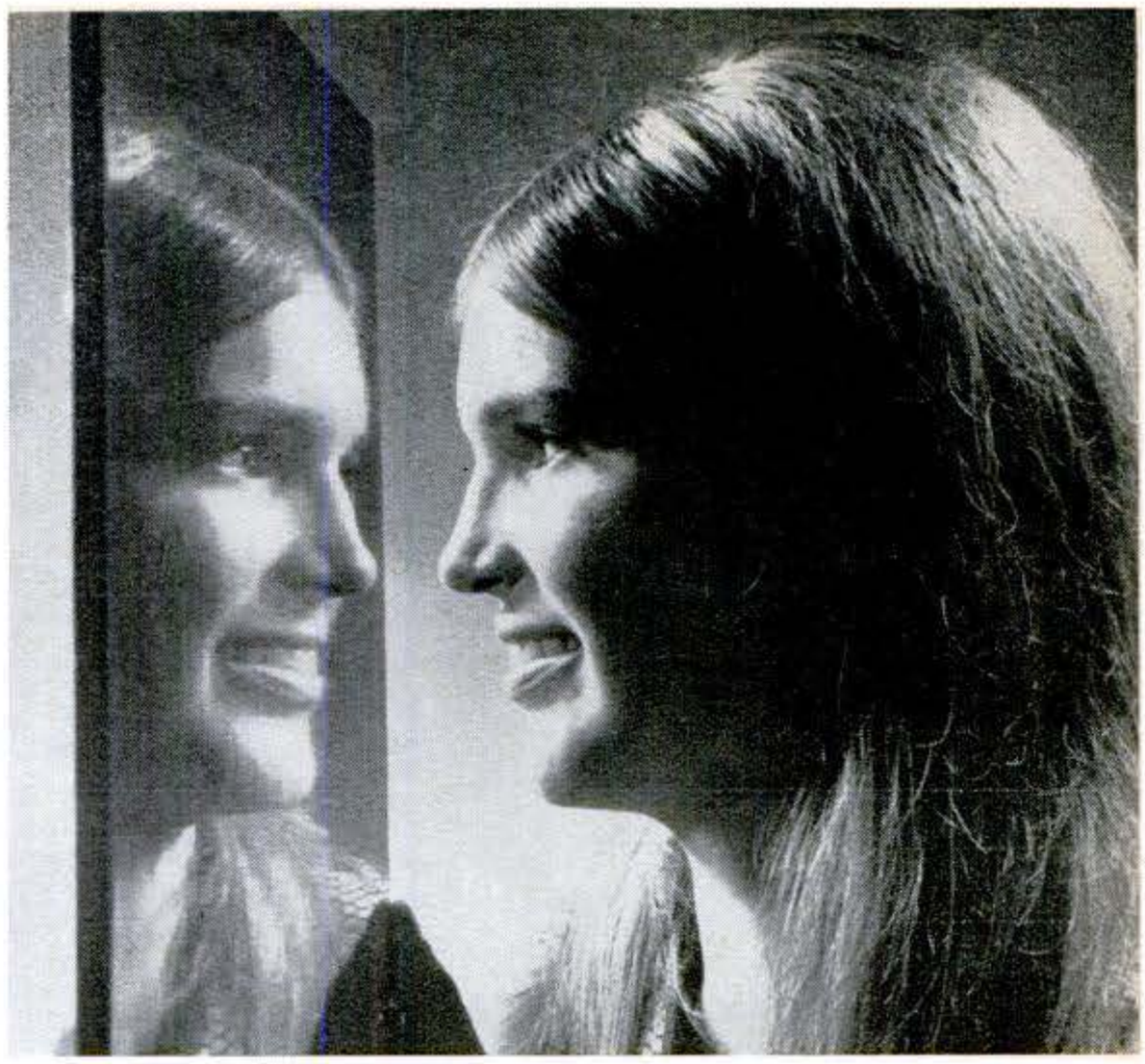
What's New IN HOME IMPROVEMENT

Mirror finish

Want a wet-look ultra-gloss coat on your table tops, floors, or patio furniture? One of three new Rez polyurethane wood finishes gives the mirror sheen shown. Called gloss clear, it's for use outdoors as well as in. The other two—satin or flat clear—offer low- or no-sheen interior coats.

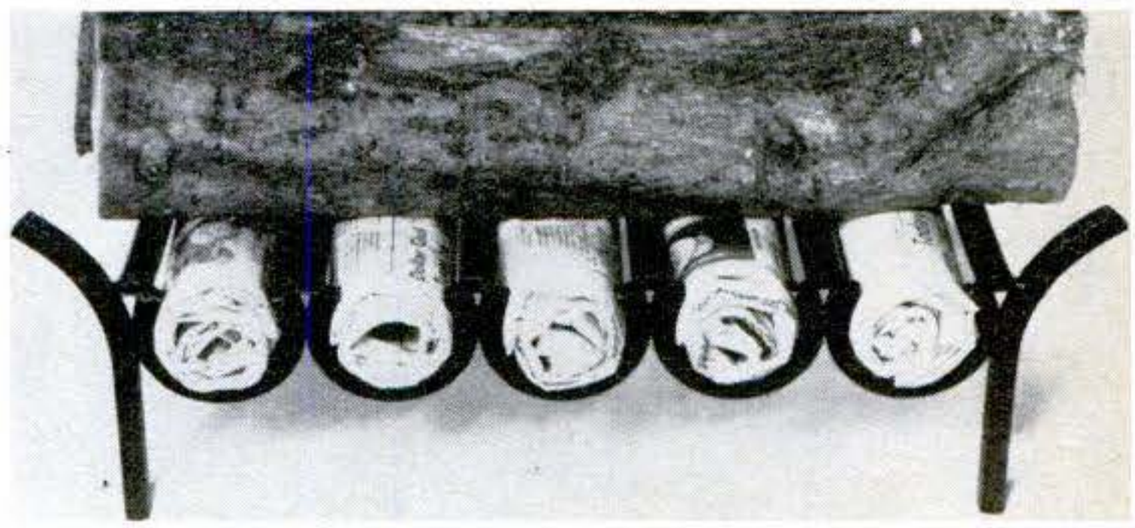


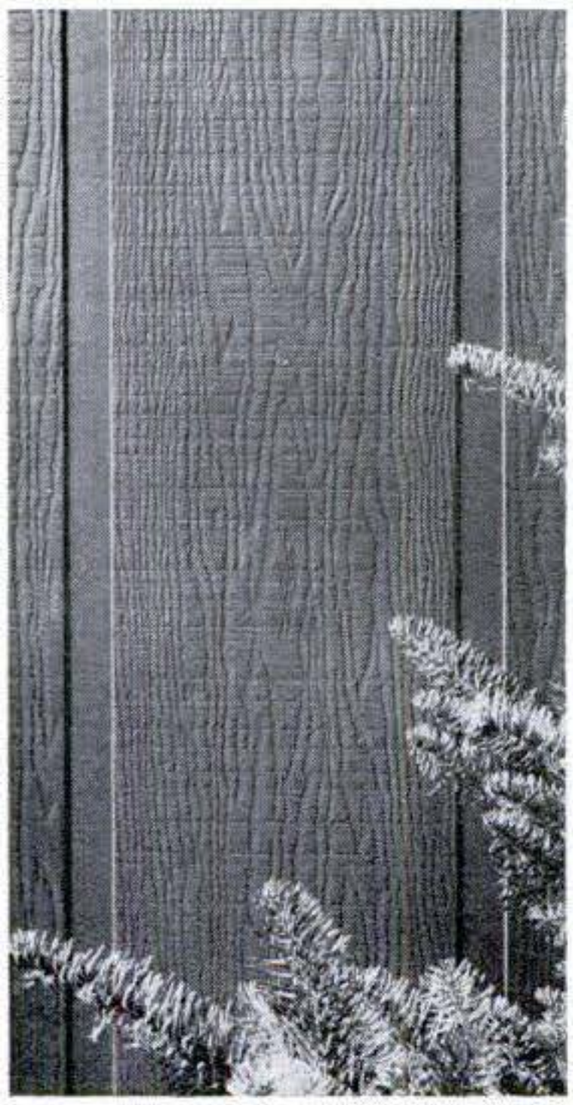
Underslung drawers

Mounted under closet shelves, tables, or workbench tops, these utility drawers double your storage. They're molded of styrene, hang from metal glides with built-in stops. In one size only—5¼" by 10" by 18". Kit sells for $6.95. Ajax Hardware, 825 S. Ajax Ave., City of Industry, Calif.

Paper-roll grate

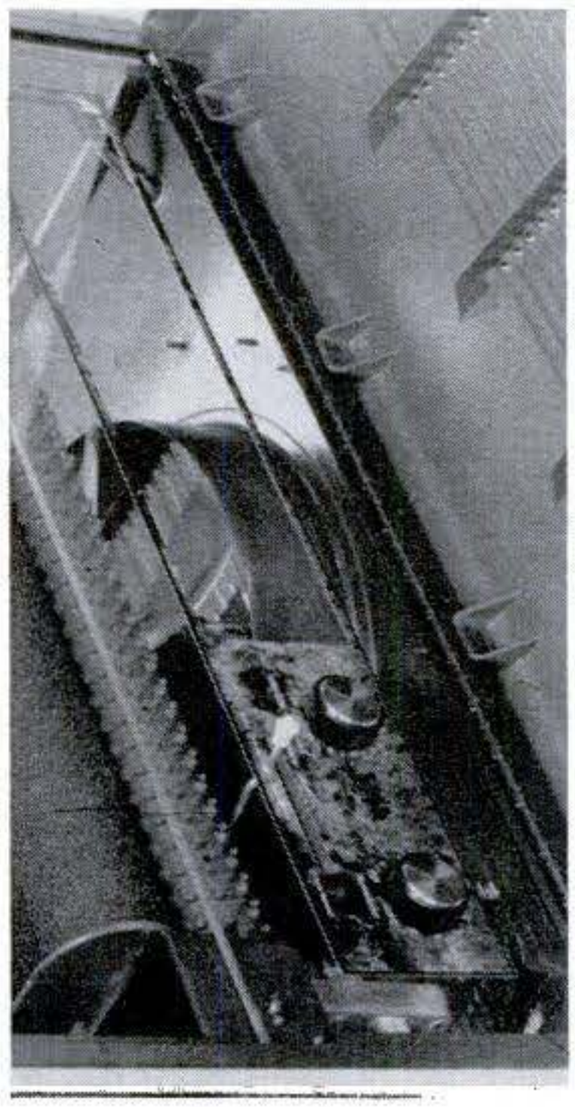
This iron grate cradles newspaper rolls to kindle your fireplace logs. It's $19.95 from (are you ready for this?) Kindelabra, Box 253, Wellesley, Mass. 02181. Another model—$10 more—holds additional rolls at log position, for an all-paper fire.





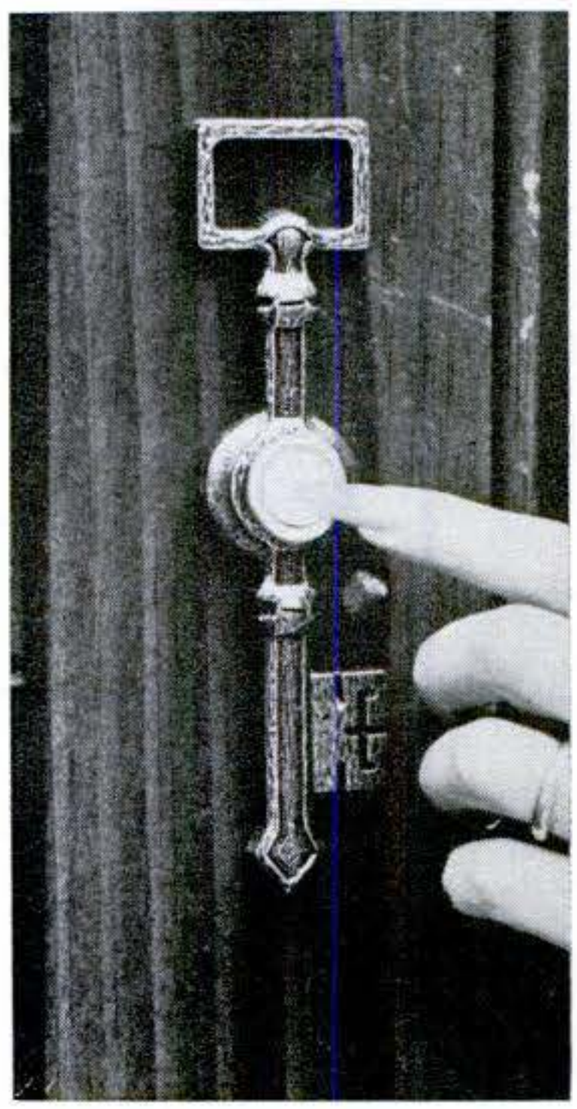
Hardboard siding

Vertical panel siding, up to 16′ long, is now offered in three textured patterns of Georgia-Pacific tempered hardboard: channel groove, reverse board-and-batten, and V groove. Panels are prime-coated and back-sealed and carry a guarantee when finished with an approved-quality house paint.



Clean humidifier

Nearly 600 fingers on this roller probe the evaporator pad as it moves around an adjacent roller, preventing buildup of mineral deposits and resultant seam separation. This feature on Arvin's self-cleaning humidifiers (seen here in demonstration model) permits a unique one-year pad warranty.



Lighted doorbell

Richly sculptured metal doorbell plates in a choice of six designs created by GE are now at hardware stores—in bubble packs with installation instructions. Sculpturesques range in price from $3.25 to $4.50 and feature a softly illuminated button that's easy to find at night.

Champagne shower

Sound expensive—and impractical? It's the name Speakman Co., Wilmington, Del., gives its aerated hand spray. Made of nonbreakable plastic, the shower produces 16 bubbly streams to eliminate splashing. It slides up or down a vertical rod mounted on the tub wall, or detaches as shown.

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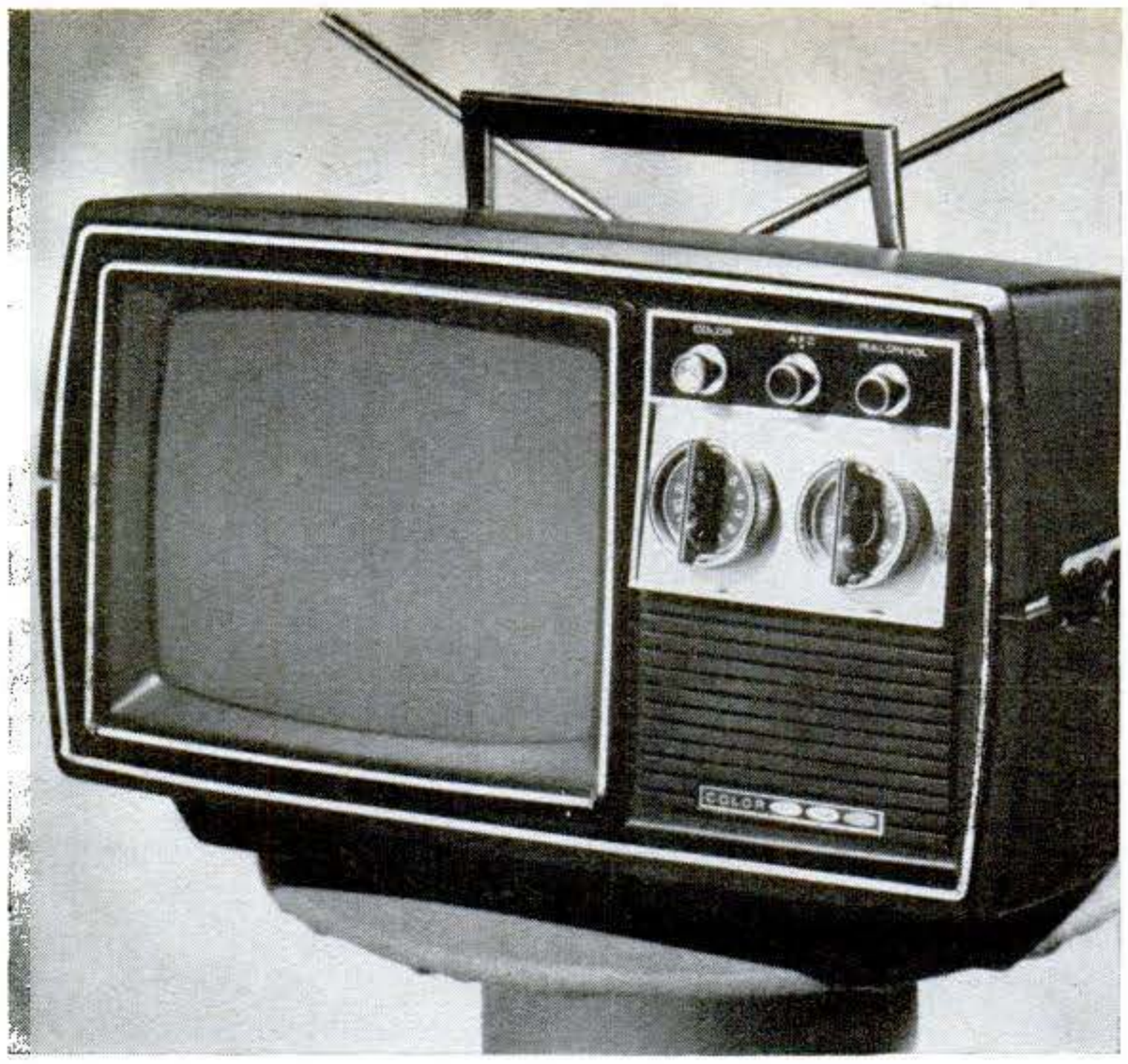
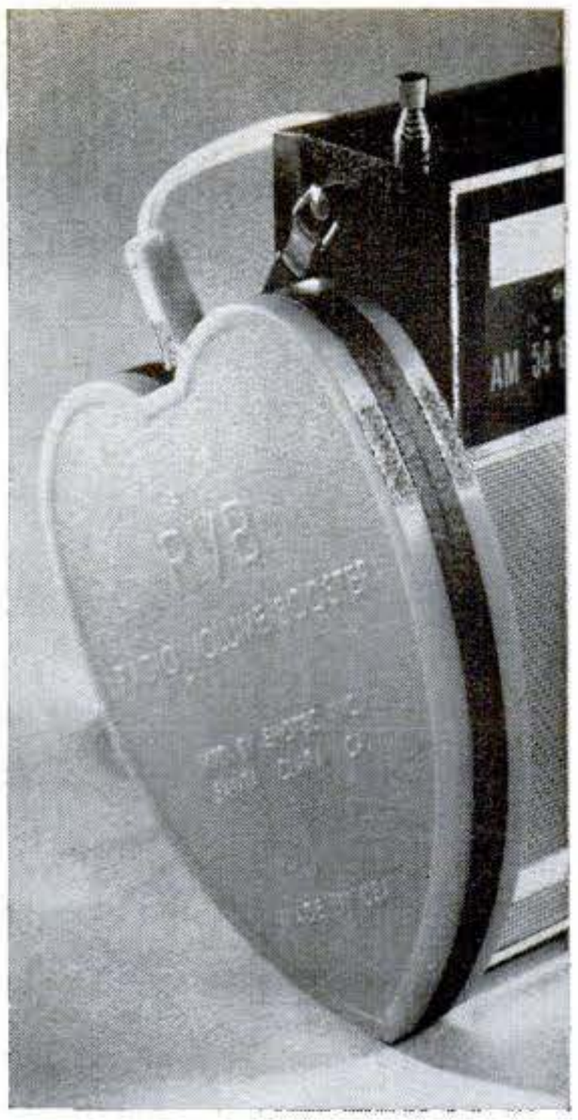
What's New
IN ELECTRONICS



Compact color

Short of space? This 25-lb. color TV portable takes up little room—it's only 10¼ inches high, 15⅞ wide, 14½ deep. The solid-state chassis gives you an instant picture on the nine-inch screen. Model 4005 is available at most Sears stores for about $300.



Volume booster

Place this radio volume booster near your AM radio and you get up to 600 percent more volume, says the maker. It improves the antenna signal—without connection to the radio or AC line. It's $7.95 from Shotec, Inc., 3393 De la Cruz Blvd., Santa Clara, Calif. 95050.

Compact stereo

Here's a new audio system that features a solid-state AM/stereo-FM receiver, BSR McDonald record changer, and four-inch air-suspension globe speakers. You get a magnetic cartridge with diamond stylus. Sylvania's ACS12WH is $199.95.

Home computing

Need computer power in your home? TeleComputer lets you lease time on giant remote computers through your telephone. Answers to problems are displayed in words, graphs, or numbers on your TV set. Cost? $695-$960. Digi-Log Systems, 666 Davisville Rd., Willow Grove, Pa. 19090.

Fast winder

Tired of waiting while your cassette machine rewinds a tape? This gadget will zip through a C-60 cassette in 15 seconds—up to 10 times faster than most recorder/players. It works with any cassette size. Executive Devices' FW-10 is $7.95 without batteries. 740 S. Locan, Fresno, Calif. 93702.

Electrostatic phones

Slip these stereo headphones over your ears for top-notch hi-fi listening. Superex's electrostatic stereophones have 10-20,000-Hz frequency response and minimal distortion. The console handles two sets of phones, and has a speaker/phone switch. Price of model PEP-77C: $99.

Tape shutoff

Now you can fall asleep, or even leave the house, while your tape player is running. The Servo-Matic 550 senses tape motion with a low-voltage switch you install; line voltage is shut off when tape stops. Kit, $22.50; wired, $35. Cymax Audio Accessories, 162 Buffalo St., Hamburg, N.Y. 14150.

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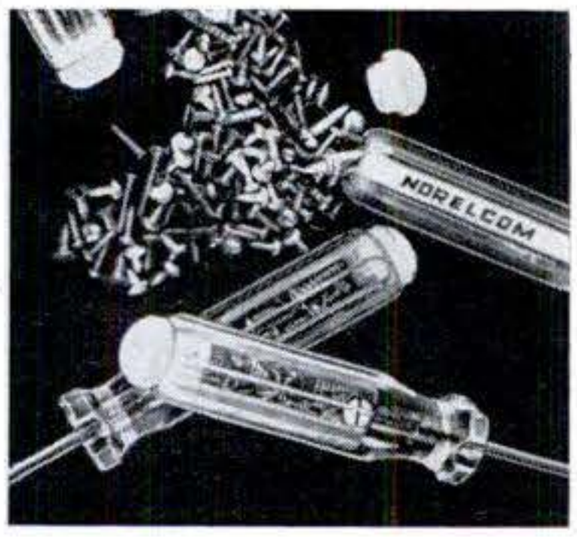
What's New
IN TOOLS

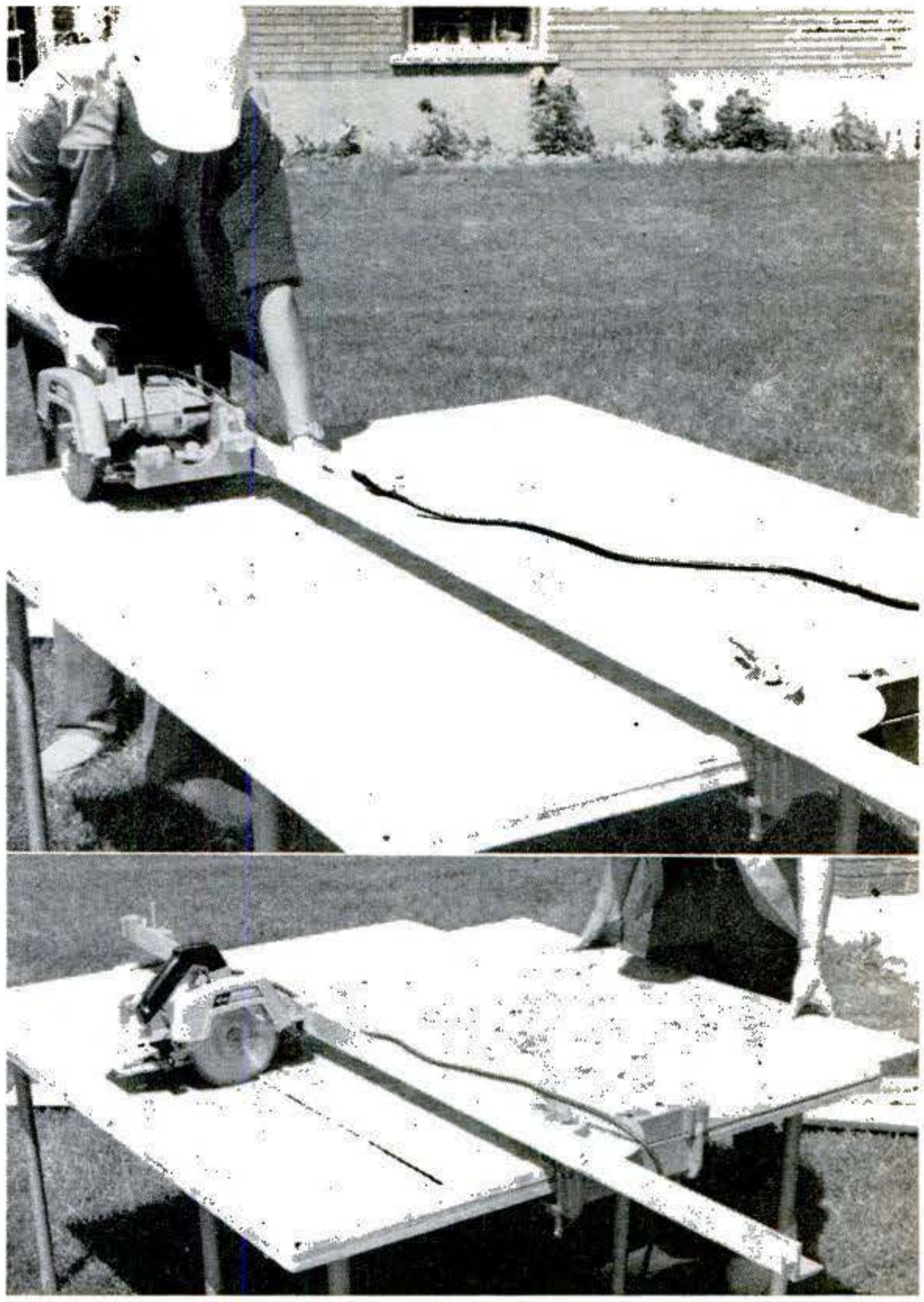


Hollow screwdriver

Here's a handy tool for keeping the right-size screw at your fingertips—just remove the cap and pick the size you need. It comes in eight different blade models for $1.69 and $1.89. They're made by Norelcom Fasteners, Inc., 200 Allen Blvd., Farmingdale, N.Y. 11735.

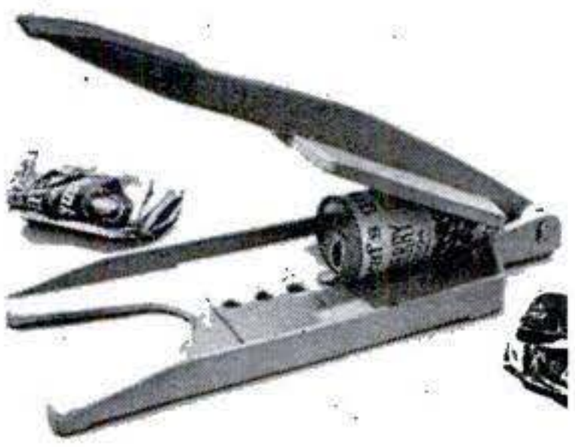
Cordless soldering

Hard-to-reach solder joints are a snap for the Iso-Tip iron. The nickel-cadmium batteries put the equivalent of 50 watts on the tip—up to 60 joints per charge. Cost: $19.95 from Wahl Clipper Corp., 2902 Locust St., Sterling, Ill. 61081.



Portable circular-saw and router guide

Clamp this guide to your work table, attach your circular saw to the carriage, and you're ready for fast, accurate cutting—all angles, rip or crosscut, and several pieces of material at once. Maximum angle cut is 48 in.; maximum crosscut, 51 in. The saw switch must be locked in when used in the ripping position. Used with a router, the unit makes precision finishing, dadoing, and edge molding easy. The carriage moves on ball bearings for quiet operation. The guide weighs 29 lbs., and has an 80-in. aluminum track. $149.50 from Protrack Industries, Box 607, Elmira, Ont., Canada. A smaller, lower-cost model is available.

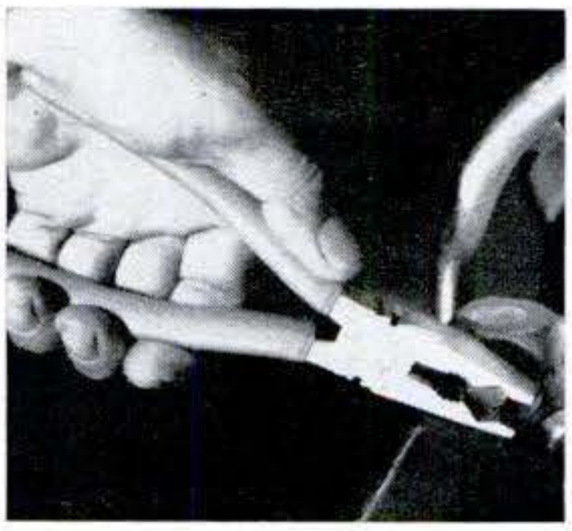


Can crusher

Flattening bulky cans for recycling or storage is simple with this Decco can crusher. A steel rib breaks the can's seam as you step on the arm. The 18-by-6½-by-2½-in. unit weighs six lbs. D. E. Carlson Co., 1024 Michigan Ave., South Milwaukee, Wis. 53172.

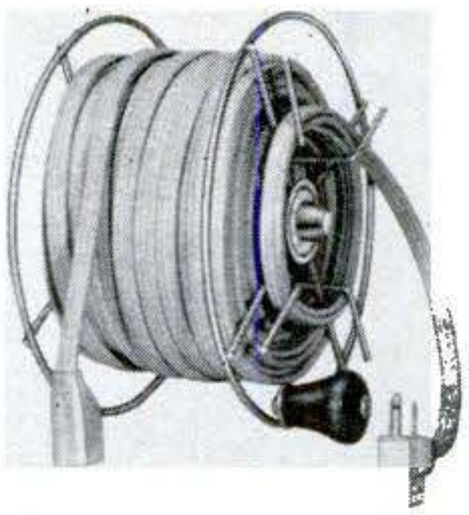
Versatile drill

With this new ½-in. drill from Rockwell, speeds can be preset and locked—forward or reverse—from 0-700 rpm. A high-torque, double-reduction gear drive delivers power from a 2.8-amp motor. Model 85 is about $45.



Nut pliers

Don't use pliers on nuts. Right? Not so with these pliers. Specially shaped openings in the tips and jaws grasp a wide range of nut sizes—and hold them. Pliers have vinyl grips, are about 7¼ in. long. $5.95 from Brookstone Co., 9 Brookstone Bldg., Peterborough, N.H. 03458.



Electric-cord reel

Ever spend time untangling an electric cord? This plated-steel reel with hardwood handle will hold up to 100 ft. of three-wire cord. Just unreel and connect both ends when you want to use the cord. It's $5.95 from Central Specialties Co., 6030 Northwest Highway, Chicago, Ill. 60631.

Floor cutter

This floorboard cutter saws through a board in 30 seconds for easy access to wiring, plumbing, or floor supports. You hold it down with your foot while rotating the blade with a ratchet handle. Delway Products, 86 Alwyn Road, Maidenhead, Berks., England.

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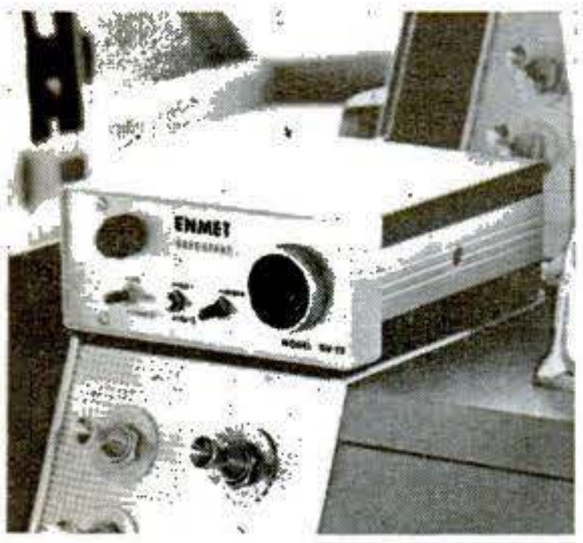
What's New
IN BOATING

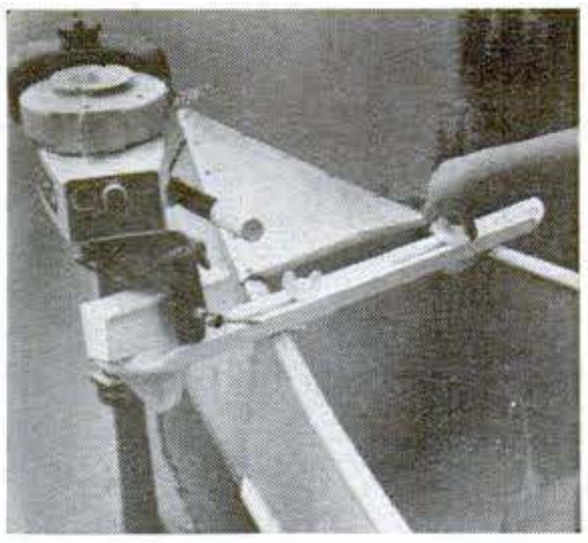
Car-topper's friend
Car-topping is easier than ever with the new Cosom one-man boat loader and hitch extender. Wide clamp gives extra firmness when the boat is lifted, and steadies the boat during transit. Cosom Corp., 6030 Wayzata Blvd., Minneapolis 55416.

Stump-proof motor
Fish a lot in shallow, stump-filled waters? Merc's new 9.8-horse motor with Glide-Angle design rides over underwater obstructions with ease. And auxiliary adjustment lets you lock the motor in a high-tilt position ideal for maneuvering in shallows.

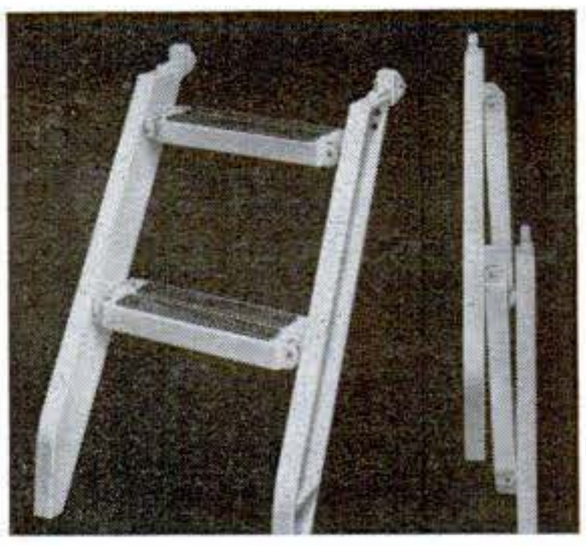
Sculling glove
Here's a slick way to stalk the lunkers—a molded plastic sculling paddle that fits hand and forearm for easy, one-hand use. The unique design gives a glove-like fit on either arm. Arm Rest is $3.95 from Rebco Products Co., Box 17435, Memphis, Tenn. 38117.



Solid-state sniffer
Heart of Safe-Start is a fuel-vapor sensor. If it detects vapors it won't let you start your boat, and it flashes a red warning light, sounds an alarm, and activates a blower to clear the fumes. Environmental Metrology, 2308 S. Industrial Hwy., Ann Arbor, Mich. 48104, makes it.



Easy-on motor mount
Want to add a small outboard to your canoe the easy way? This bracket does the trick—without tools—on either side of the canoe. Bremer Mfg., Box 548, Elkhart Lake, Wis. 53020, makes it in aluminum and stainless steel for $19.95.

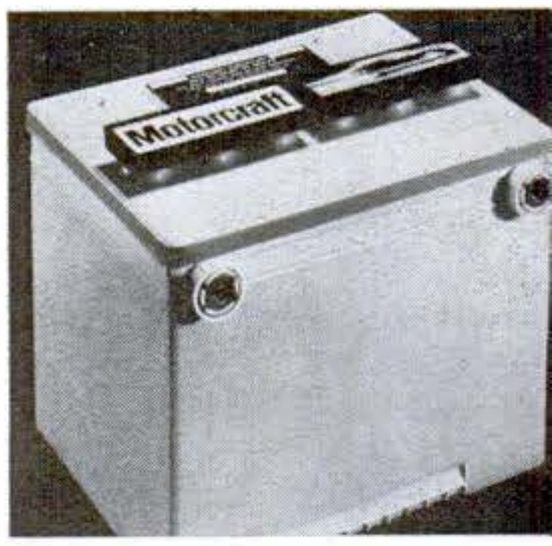


Stowaway steps
A new structural foam from Union Carbide combines with classic teak to make this ingenious stowable cockpit ladder. It floats (supporting 500 lbs. in the water), adapts from 22 to 28 in. and comes with mounting hardware. Mayfair Marine makes it for $34.95.

What's New
FOR YOUR CAR

Power saver
Smog-control devices steal power from your car engine. The Mark Ten B puts the powe back, according to Capacitance Discharge Ignition Systems, Box 1147, Grand Junction, Colo. The secret: new circuitry that extends spark duration during starting and idle modes.

Trouble winch
Hub Winch fits on your car's hub and uses a snatch bloc and cable to pull you out o mud, sand, or snow. It' $79.95 in models to fit mos cars and trucks. McCai Hub Winch Co., Box 908 Eugene, Ore. 97401, make it. Specify make, model, an rear-end type of your car



A better battery
Ford's following the trend to molded plastic batteries with side-mounted terminals. The new line of premium, heavy-duty batteries is being sold under the Motorcraft name and features thin-wall design to provide extra space inside for plates and acid. Result? Extra cranking power.

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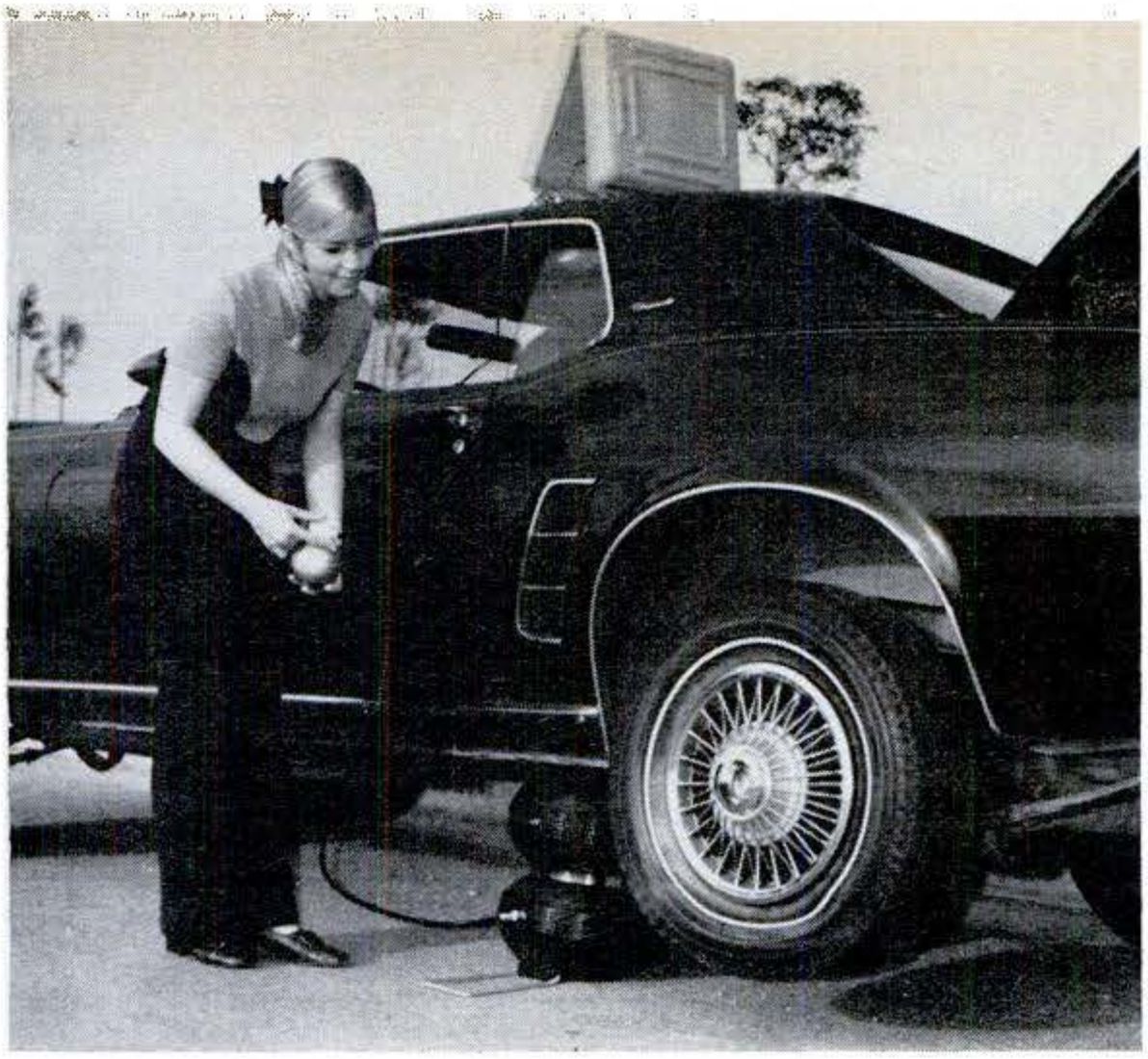
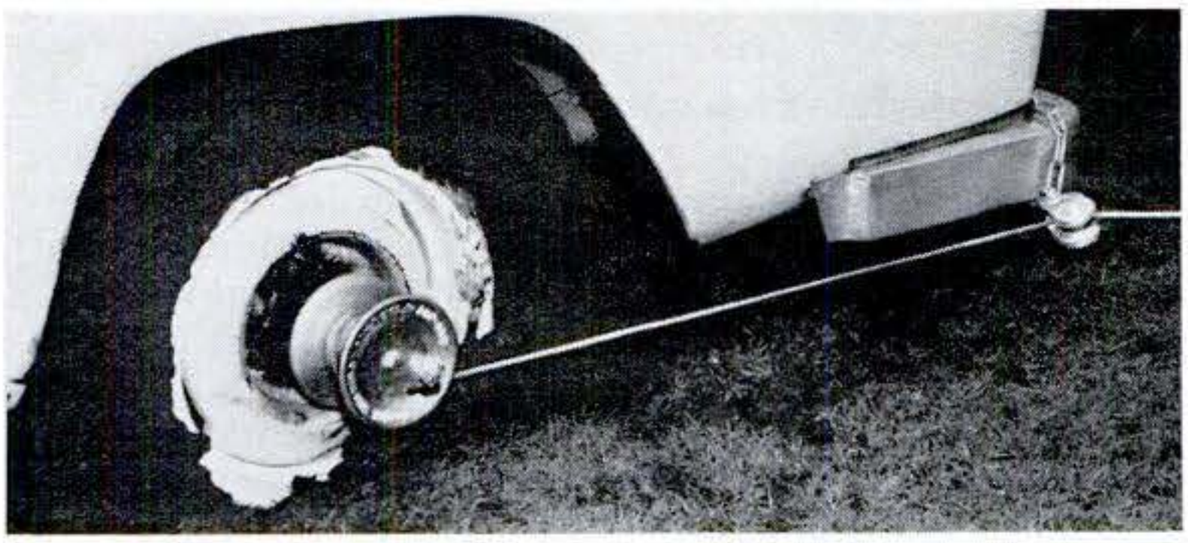
What's New IN OUTDOOR RECREATION



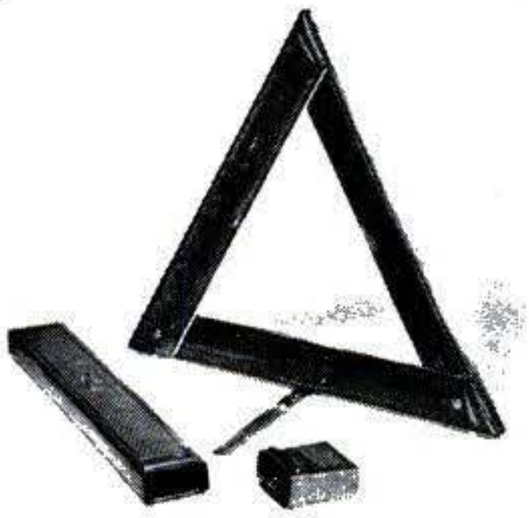
Lift it with air—put on the spare

Lift your car on a cushion of air? This plastic jack will do it, and here's how: You place a vinyl bellows under your car. Press a button on a small round container of pressurized air, and the bellows inflates via a three-ft. hose. Your car rises 18½ in. (15 for sports cars and compacts) and you change tires. Pressure in your spare a little low? Bring it up to specs with air from the pressurized container. Each "air ball" can activate the jack many times. The Bulldog Airjack is by Clayco Automotive Products, Costa Mesa, Calif.



Lazy man's voltmeter

Check your electrical system three ways without getting out of the car. Automark plugs into the cigarette lighter, checks battery under no load and full load, and checks charging circuit with motor running. Automark Ind., 641 Vermont, Palatine, Ill. 60067, makes it. Price? $6.98.

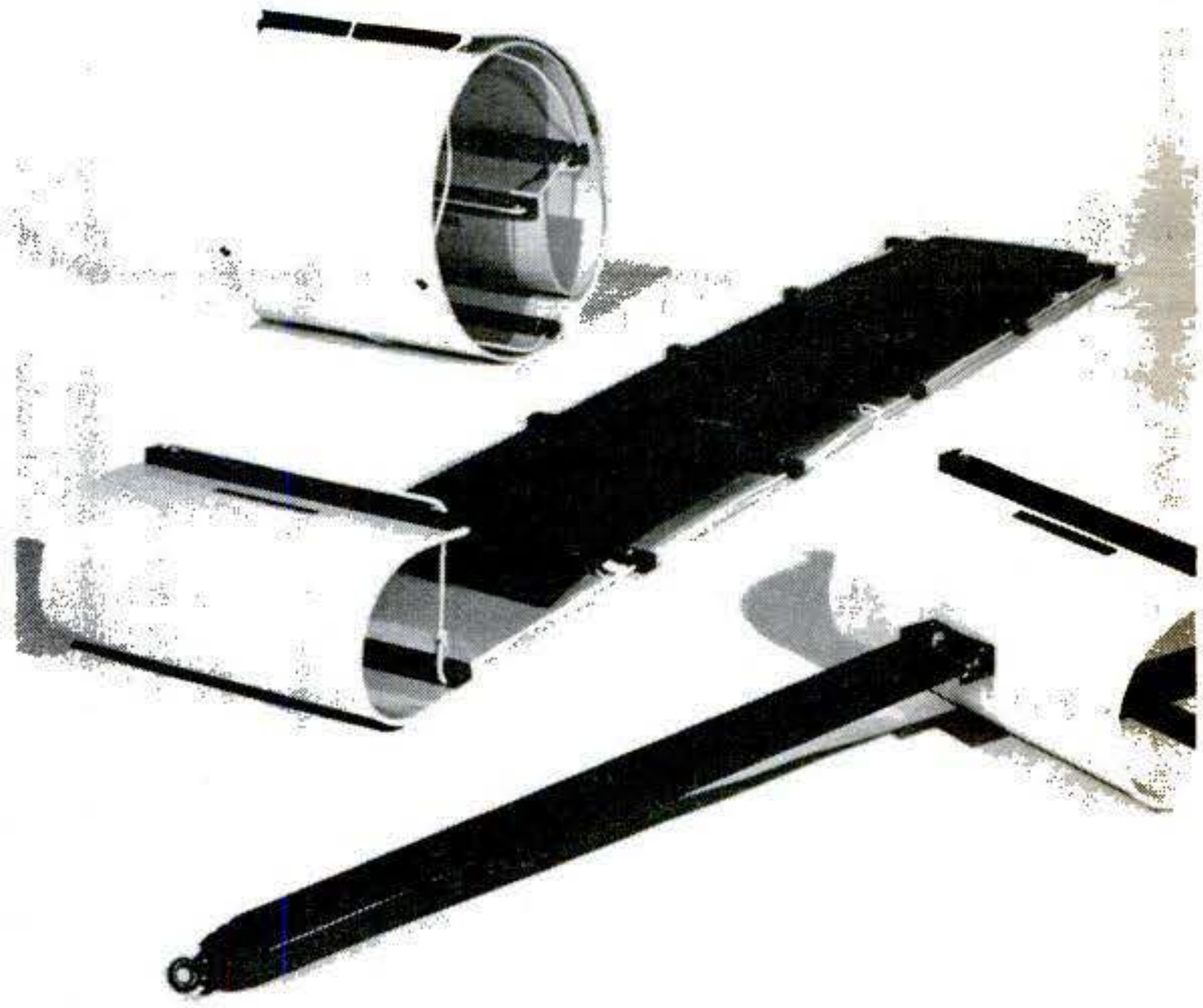


Fold-up reflector

Many countries require all vehicles to carry an emergency reflector triangle like the one above. Now it's available in the U.S. Place it on the road or rear-window shelf—it's visible up to 1,500 ft. It's $3.95 from Tradewinds, Box 92, Sherborn, Mass. 01770.

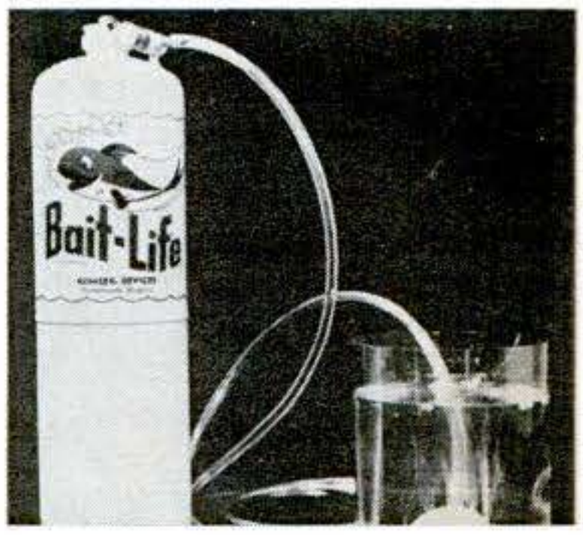
Roll-your-own sled

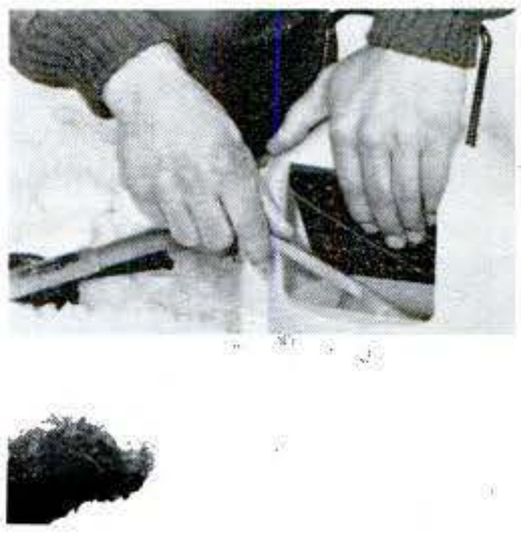
A toboggan that rolls up for transportation and storage? Right. And according to International Engineering, 1442 E. Outer Drive, Detroit 48234, it's nearly 100-percent unbreakable, and will outrun and outdistance its wooden brothers, two to one. It's shown below with an accessory snowmobile hitch.



Bait bubbler

Dead bait doesn't make it. Bait-Life keeps your bait alive. Fill the tank with air at a service station, slip its hose in your bait bucket, and get hours of aerating bubbles. Romeek Devices, 5809 Barberry Lane, Portsmouth, Va. 23703. Price: $9.95.





Antifreeze bucket

Problem: Your minnow bucket freezes solid when you go ice fishing. Solution: the Flow-Troll insulated minnow bucket. It's made by Cosom Corp., 6030 Wayzata Blvd., Minneapolis 55415. Add a little fresh water now and then, and bait stays active for days.

Paper-fueled broiler

Don't throw out the Sunday newspaper; cook with it. Fueled with a couple of sheets of paper, Small Fry broiler does steaks in six minutes. It's portable, collapsible, and $9.95 from American Dictation Systems, 2922 N. Pulaski Rd., Chicago 60641.

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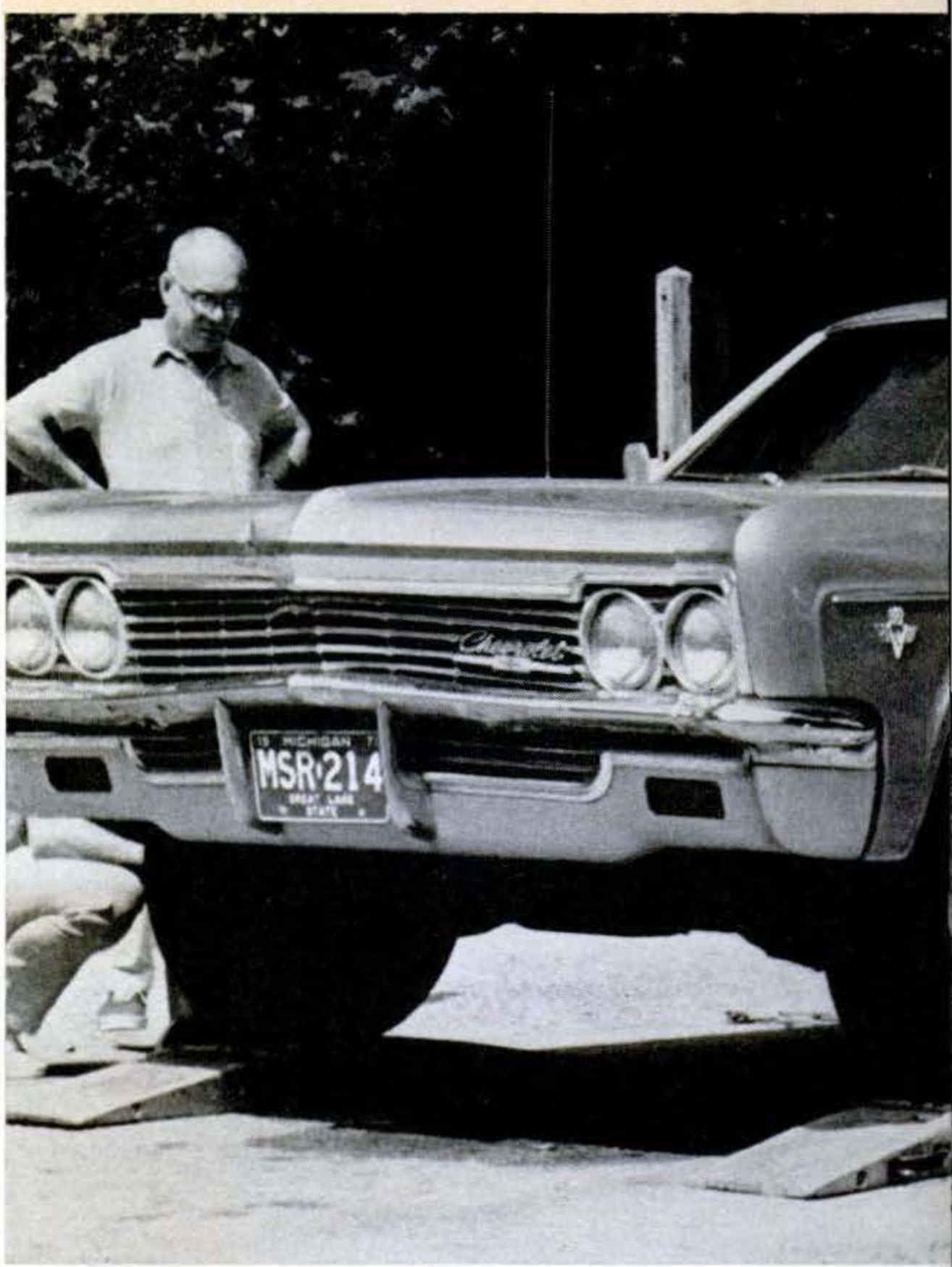
RECREATIONAL VEHICLE SURVEY 1971

Feds make the camper scene:

RV SAFETY STANDARDS ON THE WAY

You'll get a safer, better-riding vehicle, with—at last—honest load specifications if these proposed regulations go into effect

By JERRY COPELAND



Car-trailer rig undergoes inspection at Great Smoky Mountain National Park by federal team. It was one of 5,000 vehicles checked during the past year in anticipation of new RV safety standards.

The most detailed investigation into the safety of recreational vehicles ever undertaken is being completed this month by the federal government. The findings may soon lead to the enactment of stringent new safety standards that could affect the engineering and design of every type of camper.

Some 5,000 RVs were inspected over the past year during the project in federal campgrounds. In Arizona, Nevada, North Carolina, Tennessee, and Virginia, falling under watchful eyes were 3,000 travel trailers, 1,000 pickup campers, 800 camping trailers, and 200 motor homes. More than 200 brands were represented in the sample inspected by the feds.

Last summer, I drove my '71 Chevrolet/Franklin pickup camper to Great Smoky Mountains National Park in Tennessee to become one of the 5,000 camper owners whose rigs were voluntarily inspected—one of 57 surveyed that day. Here's what the inspectors looked for and how they worked.

Up on the scales. I drove my rig up onto six portable highway scales—one for each of the standard wheels and two for the tag-axle wheels my pickup is equipped with. An inspector gave me a small brochure explaining the survey and a decal that I could mount on my camper to show I had participated in the project.

While I was giving information about the make, model, size, year, and license of my truck camper, another member of the team checked tire pressures, noted the weight at each wheel, and checked the wheels for size and condition.

The whole process took less than 15

Portable scale weighs each wheel to determine load distribution. Most owners didn't know their camper's load capacity.

Large calipers measure wheel-rim width on trailer. Wheel condition, lugs, and bolt-circle diameter were also checked in survey.

Stabilizer jack goes under rear bumper prior to unhitching trailer. Some with negative tongue loads tipped backward.

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minutes. As I looked at a copy of the figures jotted down on the inspection form, I got a shock. The inspector had noted 65 pounds in my front tires. That's more than twice what I normally carry.

I reported this to Warren Gechei, project supervisor for the Department of Transportation, who personally rechecked the pressure. Gechei found about 32 pounds of air in the tires and corrected the form. I couldn't help wondering how many mistakes like this took place during the survey.

I spent the rest of the day watching other rigs being inspected and talking to DOT officials to find out more about the project.

Spotlight on trailers. Trailers were inspected somewhat differently than pickup campers and motor homes. Vehicles pulling trailers drove up until their back wheels were on a ramp. Using a large "ruler" on the ground, the team measured the distance from the drive axle to the hitch ball, mounting point of the hitch, front of the trailer, trailer axles, and the rear of the trailer.

The height of the hitch ball was also measured, and all wheels of the trailer and towing vehicle were weighed with the rig fully loaded. The trailer was then uncoupled and the tongue was lifted off the ball with a jack. The wheels were now weighed again, and inspectors checked ball size and couple for match. Hitches were also checked for load rating and to determine whether the coupler was equipped with a safety pin, safety chains, or antisway devices.

Team members then crawled under trailers to check springs and axles. The number of leaves, stack height, and width and length of springs were recorded, as were the axle width or diameter.

Owners of the trailer rigs were questioned about the origin of the hitch and towing vehicle to determine whether they had factory-equipped "towing packages." The team also noted whether there was a gross-vehicle-weight (GVW) plate on both car and trailer—and whether the owner knew they were there.

During the inspection, Polaroid photos of the complete rig were made, along with extra photos of any unusual parts.

All types of rigs passed through the line. Tent trailers predominated on the day I watched, but by the time the survey ends, some time this month, the number of vehicles and the ratio of types will have been met exactly.

I noted several instances of potential danger in the rigs I saw. Cars equipped with 1⅞-inch hitch balls were pulling trailers with two-inch coupler sockets. Many had no coupler safety pin, and either no safety chains or such flimsy ones as to be virtually useless.

A few trailers reflected a negative tongue load. When the trailer was uncoupled, the tongue rose up, indicating the vehicle was overloaded in the rear. The survey team had to place a jack under the rear of each trailer to avoid accidents while making this check.

DOT observations agreed with mine. Officials told PS that inspectors had discovered wheels that were failing, bent axles and frames, tires that were going, leaky gas tanks, and other hazardous conditions.

Most shocking was the discovery that at least two classes of trailers were overloaded before they were sold. That means they were probably even more dangerously overloaded once the owners stowed all their gear in them for trips.

What's it all about? Some time later, I flew to Washington to review with Gechei and Roman Brooks of DOT what the agency hopes to obtain from

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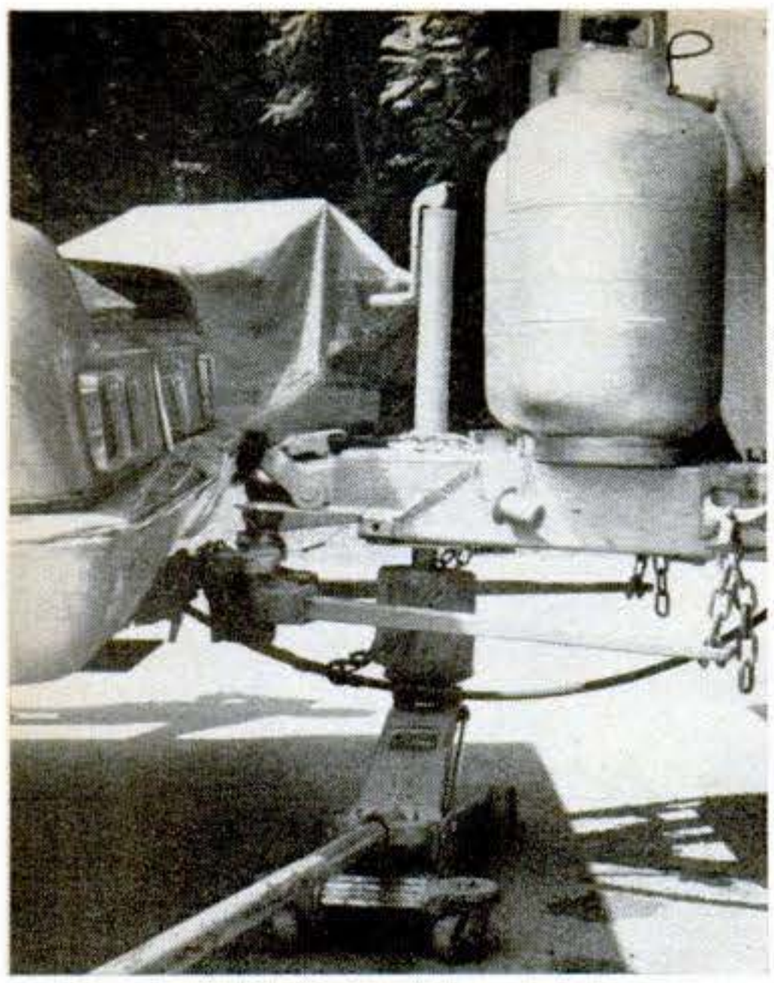

Hydraulic jack raises trailer tongue off hitch, so car and trailer weights can be checked independently by federal inspectors.

the 5,000-vehicle survey. They told me that the data they collected will help to develop future safety standards for RVs. There are already 19 federal vehicle-safety standards that affect RVs, and one major docket is pending that would provide consumers with much needed information to help match their camper bodies to the right pickup trucks.

A docket is a notice to the public and to manufacturers of a proposed new standard in construction that DOT is considering.

What's on the docket? The major docket pending at this writing is No. 71-7, "Center of Gravity for Truck Cargo and Campers." It proposes that truck manufacturers specify on a placard attached to the dashboard or glove-compartment door, and in the owner's manual, the limits for the placement of the center of gravity of loads at 50, 75, and 100 percent of the truck's cargo. It must specify vertical, lateral, and longitudinal distances from reference points to the rear axle.

For campers, the docket requires "the camper manufacturer to determine the gross camper weight and the center of gravity of the camper when loaded to gross camper weight." The information would be provided on a placard located on the exterior left side of the camper, giving the longitudinal (rearward or forward), lateral (inboard), and vertical (downward or upward) location, in the form of two crossed lines (like a plus sign).

The placard would also carry the manufacturer's name and gross camper weight and be located so that the mark or plus sign would be at the center of gravity point. If that was not possible because of glass or some other surface to which a label couldn't be attached, the placard would give the measurements from its mark to the center-of-gravity point. A sketch or diagram is also required in the owner's manual.

In addition, the camper manufacturer would have to place in each storage compartment a label specifying the recommended weight for that compartment as indicated by a sketch or diagram showing the center-of-gravity point. In determining gross camper weight, all fluid containers must be filled to capacity and 150 pounds included for each "designated occupant sleeping position."

The docket also covers the same sort of requirements for incomplete vehicles—motor-home chassis and vehicles that are built especially for later completion by a recreational-vehicle manufacturer.

This docket was issued on April 1, 1971, and has a proposed effective date of September 1, 1972, which would give RV manufacturers time to conform. It would also be concurrent with the 1973 truck introductions.

Action on dockets relating to trailer-towing performance, hitches, couplings, safety chains, and trailer brakes has been held up pending a study of the findings of the survey, I was told. You might expect renewed action on these once the data from the survey is completely analyzed, DOT spokesmen told me.

The big surprise. What has emerged so far from the preliminary findings, DOT officials say, is the great vacuum of information about trailer and camper load-carrying capabilities. The actual capability of most camp-

[Continued on page 130]

A reporter's personal view:

What Still Needs to Be Done

The RV survey just completed in the national parks should point the way to badly needed new standards in the manufacture of campers (as well as vehicles that pull the trailers or carry the campers) and motor-home chassis.

But I am disturbed because some important points were not included in the survey. No checks were made on trailer breakaway devices or pickup-camper tiedowns. Breakaway devices are an important safety feature that should be required on every trailer equipped with brakes. If the trailer breaks loose due to a hitch failure, say the ball breaking off, a switch, fastened to the tow vehicle with a cable, is operated by the pull on the cable.

The switch is connected to the trailer brakes and electrical system, or its own battery, and activates the trailer brakes immediately. My observations of trailer connections show very few breakaway switches in use, and **most** of these are connected incorrectly. The loop at the cable end should be fastened to the car frame. Then if the trailer ball or ball mount breaks off, the cable will pull the switch to operate it. Invariably, the trailerist drops that loop **over** the ball and if the trailer breaks loose, the cable goes with it.

This is usually the case with safety chains, too. They should be fastened to the trailer yoke securely, crossed, and then connected to the frame of the car. The chains should be a little longer than the cable on the breakaway switch so that it will operate the switch before the chains catch the tongue as it drops down. I noted that the DOT survey, while checking for use of safety chains, made no record of how they were fastened. The hitch platform is a good secure place for both the safety chains and the cable to the switch.

Only 32 states require breakaway switches to stop a trailer if it breaks loose, and enforcement is lax. Another drawback: If you live in a state that does not require such a device, you can travel in any other state that you wish without it.

I noted, too, that trailer brakes were checked for type, but not for number. Many travel trailers with tandem axles have brakes on only two wheels.

Pickup-camper hold-downs are important, too. Here again, probably 95 percent of campers in use are unsafely fastened to the truck. Tiedowns that hold a camper to the pickup box are inadequate; the box is not built for such stresses. The thin sheet metal can tear and the box can work loose at its own attachments. The forces of wind, plus a camper's high center of gravity, make it necessary to fasten to the frame of the truck itself.

The greatest problems in RV highway safety involve weight distribution. Most RV manufacturers do not disclose true weights of their campers and trailers. All offer the same excuse: "Make the others do it and I will, too. Until they do, I can't afford to." Still, within the past year, a few manufacturers have been indicating true weights.

Another big problem is the misrepresentation of products and capabilities by RV and automobile dealers. Despite the inability of some trucks to carry a camper safely, far too many truck salesmen will sell a truck to a customer for that purpose. Check specifications carefully for springs, gross vehicle weight, and especially tires.

A federal standard on center of gravity would be welcome. I believe that the pending docket #71-7 has a lot of merit, but, in its present form, would be impossible to meet or enforce. The government should establish a practical figure on the amount of weight that a family will need to carry instead of leaving it up to each individual manufacturer.

Despite these drawbacks, much good can come from government supervision of RV safety. I believe that new standards on wheels, trailer tires, axles, coupler pins, and safety chains would be welcomed by all campers.—Jerry Copeland

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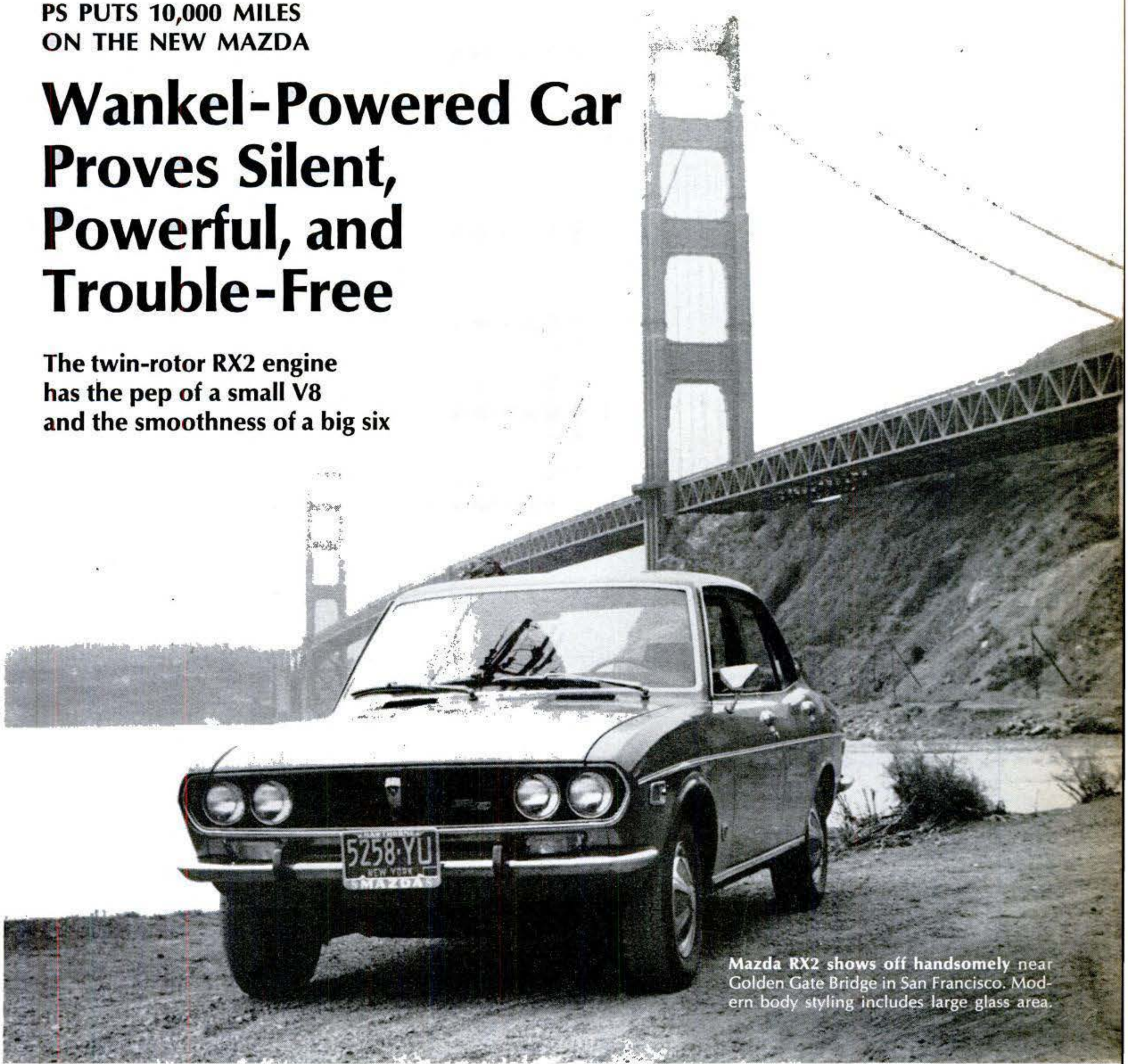
PS PUTS 10,000 MILES ON THE NEW MAZDA

Wankel-Powered Car Proves Silent, Powerful, and Trouble-Free

The twin-rotor RX2 engine has the pep of a small V8 and the smoothness of a big six



Mazda RX2 shows off handsomely near Golden Gate Bridge in San Francisco. Modern body styling includes large glass area.

By **JAN P. NORBYE** / *PS Automotive Editor*
JIM DUNNE / *PS Detroit Editor*
and **JIM DAVIS** / *PS West Coast Editor*

We have just completed driving a Mazda Rotary engine car 10,000 miles—11 years after we first wrote about the Wankel. We can now report the Wankel has come of age with Mazda's version of the famous rotary engine.

Our rotary-engined Mazda was driven by five PS editors and run through our standard tests on the track at Bridgehampton. Drivers' reports and test results follow.

Jim Davis: I picked up the car from the California dealer, used it for a week in the Los Angeles area, then drove it to San Francisco for its 600-mile service. Only one small problem: The accelerator pump was sticking slightly, and that was rectified. Then I headed for the hills—Nevada, Utah, Arizona, Colorado.

Going downhill in the Rockies on closed or light throttle, I was bothered by backfiring at high speed, bucking at low speed. At Sweet Spring, Mo., although the car had 3,129 miles, the dipstick showed oil level down less than a quart. I was getting 16-20 mpg on regular fuel. From Columbus to Detroit the engine ran faultlessly under load, but the idle was getting rough.

My reaction to the RX2? I phoned the boss and told him I wanted to buy the car. I fell in love with it.

Jim Dunne: I took over the car with 4,280 miles. First I cleaned the four spark plugs and got an oil change. Then I used the Mazda for everyday driving around Detroit, plus a number of short trips to Flint, Lansing, and Frankfort. Fuel consumption stabilized at 18.5 mpg, and oil consumption sank. At 6,226 miles *Continued*

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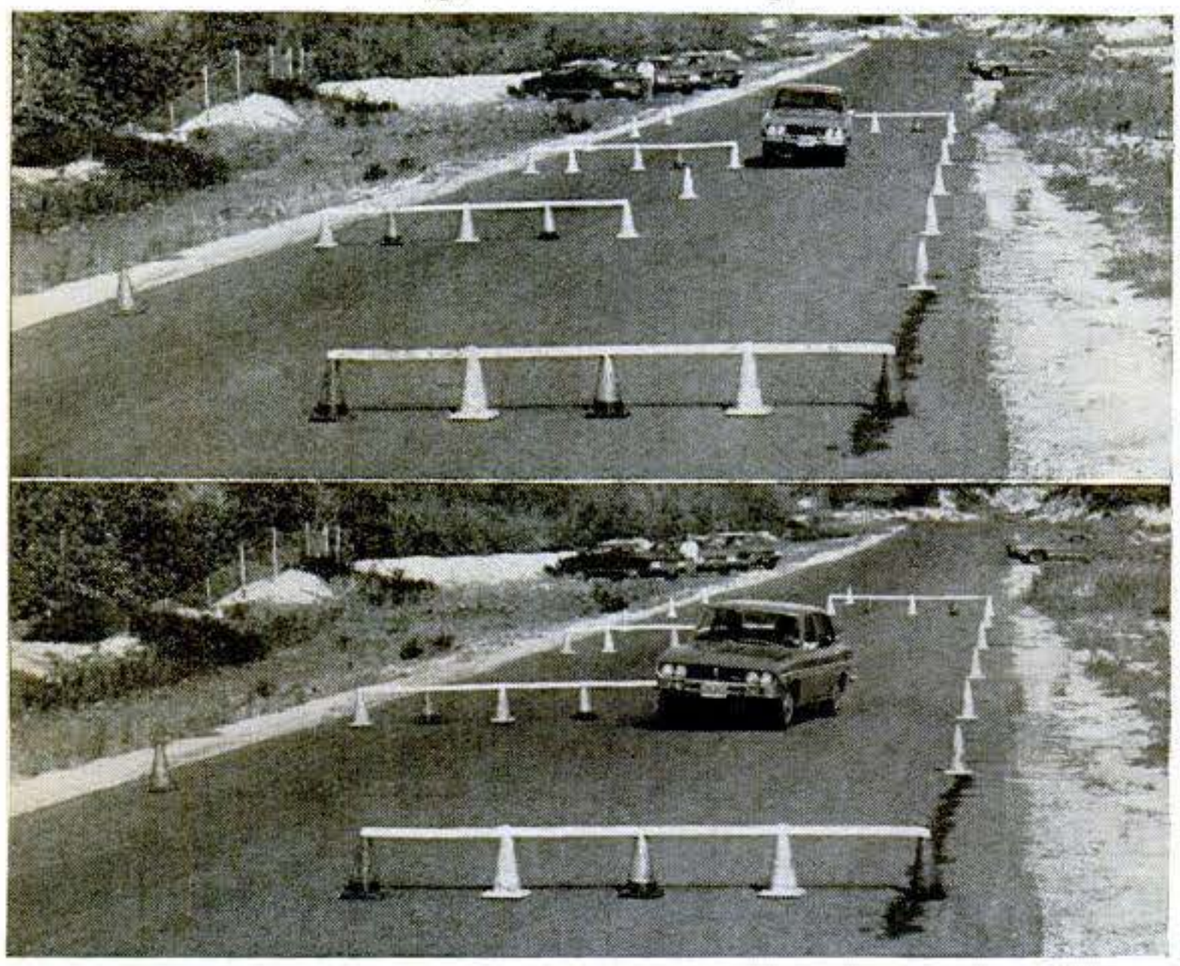
The Mazda is an attractive compact family sedan with sports-car performance,

Hill-climbing was a breeze for the Mazda, here pausing briefly at the summit of Loveland Pass, Colo.

Overall length of the RX2 matches the 1931 Auburn, but Mazda is considerably lower and lighter than the old classic.

Stable and manageable at all speeds



Mazda was one of the fastest cars ever tested in lane change, with negligible roll and accurate steering response.

I set out for N.Y. via Toledo and Route 80 through Pennsylvania. Cruising at 70 mph and 4,000 rpm, the engine is hardly audible. The strong low-range torque plus the wide speed range puts the RX2 way ahead of piston-powered cars of similar horsepower rating, weight, and price.

Jan Norbye: I got the car with 7,251 miles and drove it from New York City to Bridgehampton race circuit on Long Island. The power and smoothness of the engine impressed me. The Mazda went through our handling tests at uncommonly high speeds, proved to have excellent brakes, and showed no ill effects after a lot of full-throttle driving at the track. Steering is a little vague in near-straight position, and the rear axle can be shaken loose on country roads, but this car handles better than many sports cars. Ride comfort is up to U.S. compact-car levels. At 8,028 miles the car was back in the city to get its plugs cleaned.

Ray Hill: Coming out of the Lincoln Tunnel, I headed for Knoxville, Tenn. Rambling through hills near Cumberland Gap, Ky., I took most grades in top gear. On one of the crookedest roads I know—Route 25E near the Kentucky border—the Mazda stayed under full control at speeds I wouldn't have tried with most cars.

It even saved my life. I was doing 60 when a Toronado

Wide grille and dual headlights successfully cover up the RX2's narrow track and body. Styling also makes car look low, despite its comfortable 56-inch height.

Instrumentation is unusually complete, and small controls include choke and hand throttle. Precise, narrow-gate gearshift is exemplary, but synchromesh is not up to U.S. gearboxes.

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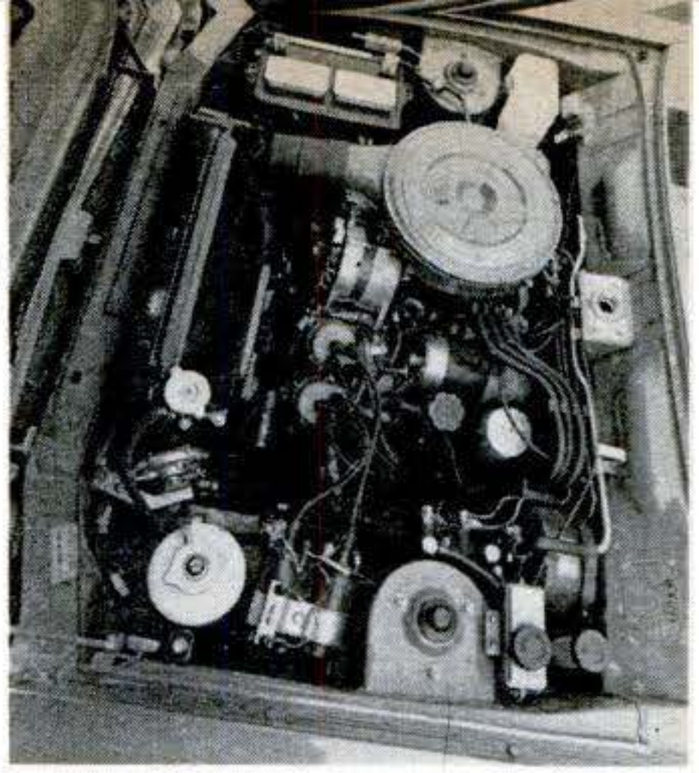
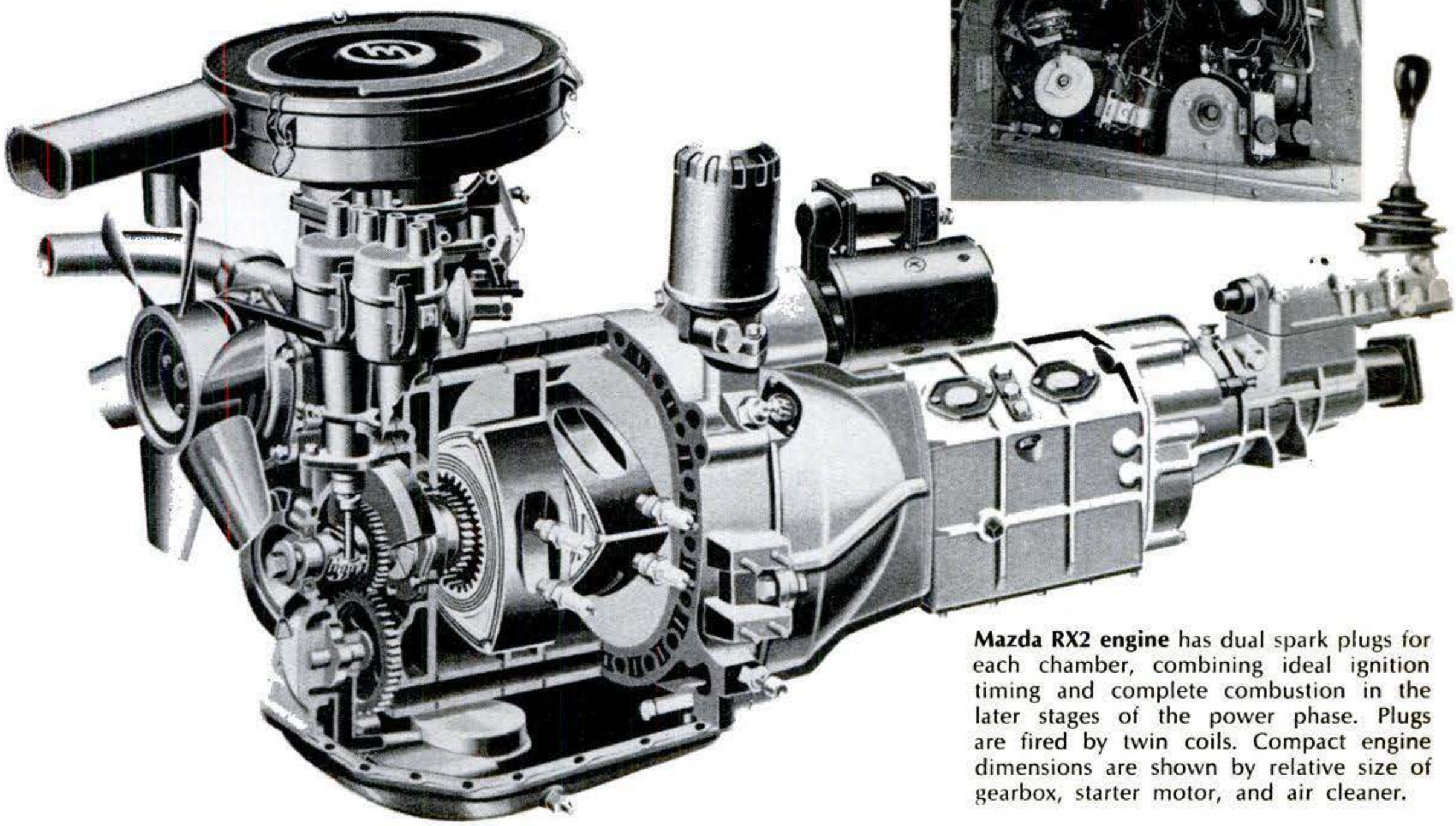
operating economy, and a remarkably modest price



Service accessibility under forward-hinged hood is first class, especially for ignition and electrical items.



Mazda RX2 engine has dual spark plugs for each chamber, combining ideal ignition timing and complete combustion in the later stages of the power phase. Plugs are fired by twin coils. Compact engine dimensions are shown by relative size of gearbox, starter motor, and air cleaner.

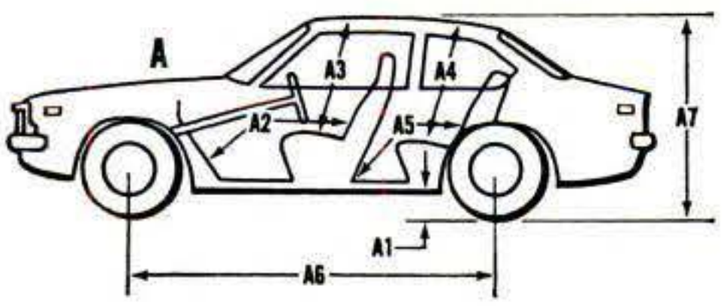
pulled out of a side road, saw me coming, panicked, and stopped right in front of me. I jerked the wheel hard right (toward the ditch), left again, and streaked past on the shoulder with inches to spare. A lesser car would have slammed broadside into the Toronado.

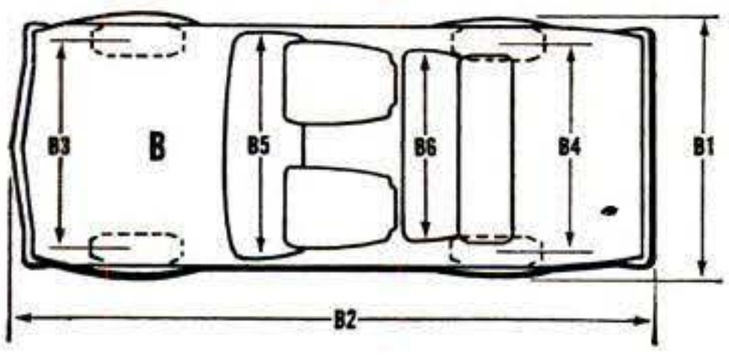
I got 16 mpg in the mountains, 18 mpg on turnpikes. When I pulled up at my apartment in New York, the odometer read 10,231 and the car ran as good as ever.

Hubert Luckett: I drove the Mazda for a weekend, and I too was impressed. The Wankel engine as built by Toyo Kogyo (makers of the Mazda) is definitely out of the experimental stage, and on the basis of our 10,000-mile experience, I believe it could go at least 60,000 miles before needing an overhaul. That's the figure Toyo Kogyo gives as the life expectancy of the carbon-and-metal apex seals on the rotors. Replacing them is equivalent to a ring job on a piston engine—and while 60,000 is below average for sixes and V8s, it is comparable to some small four-cylinder units.

The Mazda RX2 sets high standards for a Wankel-powered compact, and manufacturers just getting started in Wankel programs will find it a tough act to follow. PS

FACTS ON THE MAZDA RX2 SEDAN





DIMENSIONS (inches)	
A1 Ground clearance	6.0
A2 Front leg room (max.)	43.0
A3 Front head room	37.0
A4 Rear head room	35.0
A5 Rear leg room	37.5
A6 Wheelbase	97.0
A7 Height	56.0
B1 Width	62.0
B2 Length	163.0
B3 Front track	51.0
B4 Rear track	51.0
B5 Front hip room	23 (x2)
B6 Rear hip room	49.0

SPECIFICATIONS	
Engine type	2-rotor Wankel
Displacement (cc)	2,292
Displacement (cu. in.)	140
Compression ratio	9.4:1
Carburetion	One two-stage 4 bbl.
Hp (SAE) @ rpm	120 @ 7,000
Torque (SAE) @ rpm	110 @ 4,000
Transmission	Manual 4-speed
Axle ratio	3.70:1
Tires	Bridgestone radial
Tire size	165 SR 13
Turning diameter	31.0 ft.
Turns, lock to lock	3.8
Brakes	Disk/drum
Fuel tank (gal.)	17.3
Trunk room (cu. ft.)	12
Liftover height (in.)	32
Curb weight (lbs.)	2,270

TEST RESULTS	
Acceleration 0-60 mph	14.35 sec.
Acceleration 0-80 mph	25.45
Acceleration 25-70 mph	16.85
Brakes (cool) 60-0, distance	145 ft. 5 in.
pedal pressure	145 lbs.
Brakes (hot) 60-0, distance	133 ft. 8 in.
pedal pressure	165 lbs.
Lane-change speed	63.55 mph
Slalom speed	29.1 mph
Fuel mileage	17.9 mpg
Oil consumption	4,000 mpq
Noise level, 30 mph (smooth)	66 dbA
Noise level, 60 mph (smooth)	74 dbA
Noise level, 30 mph (rough)	71 dbA
Price (California)	$2,750

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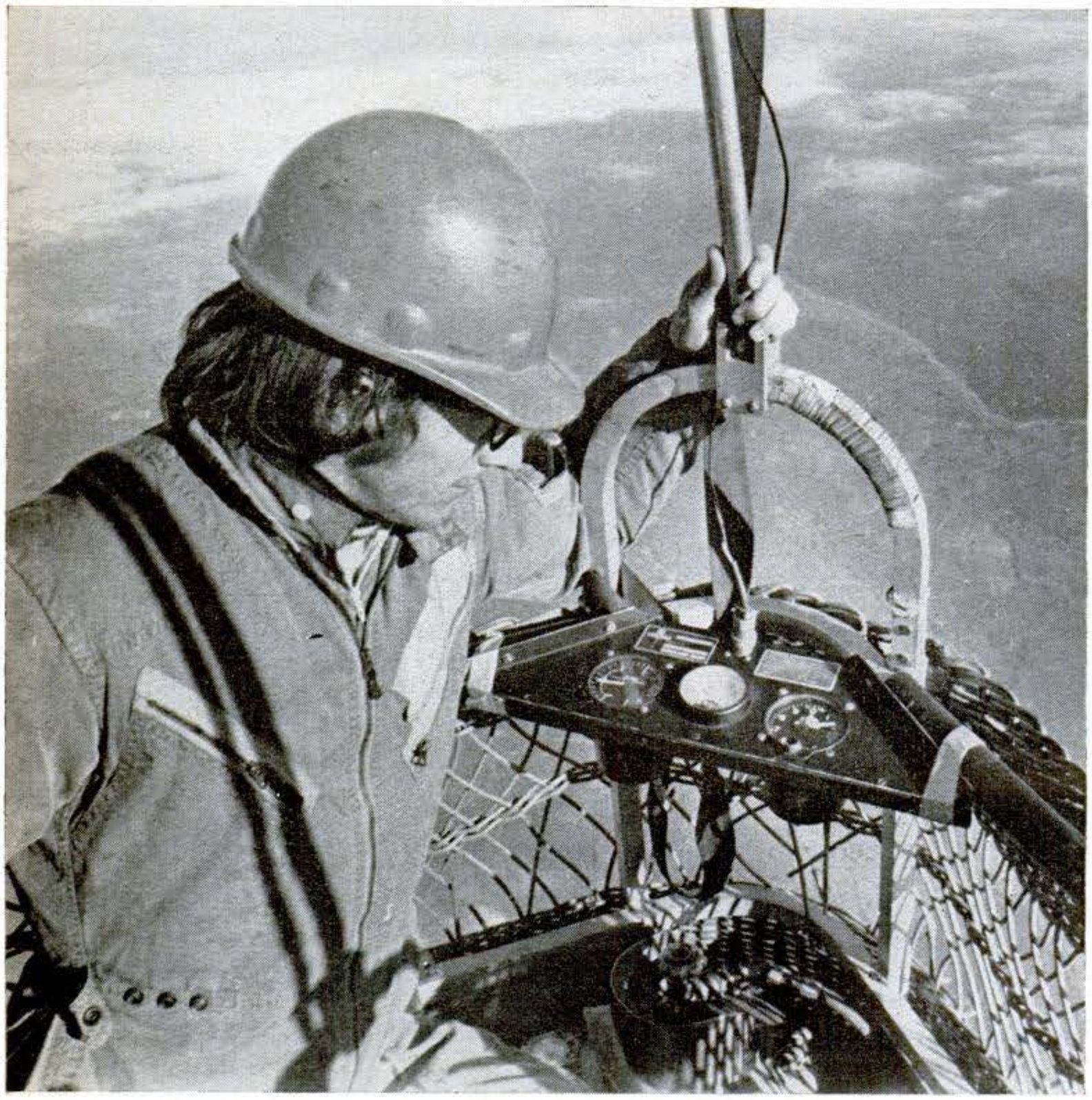
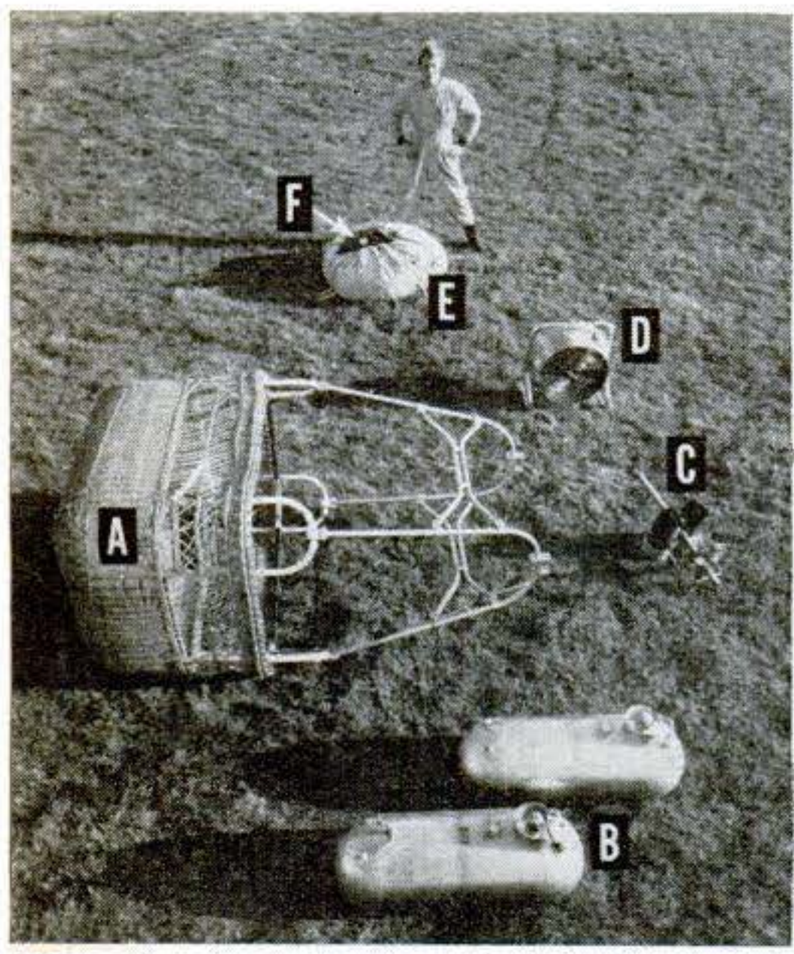
Moving with the wind thousands of feet up, or drifting across treetops—you can have a ball in a hot-air balloon

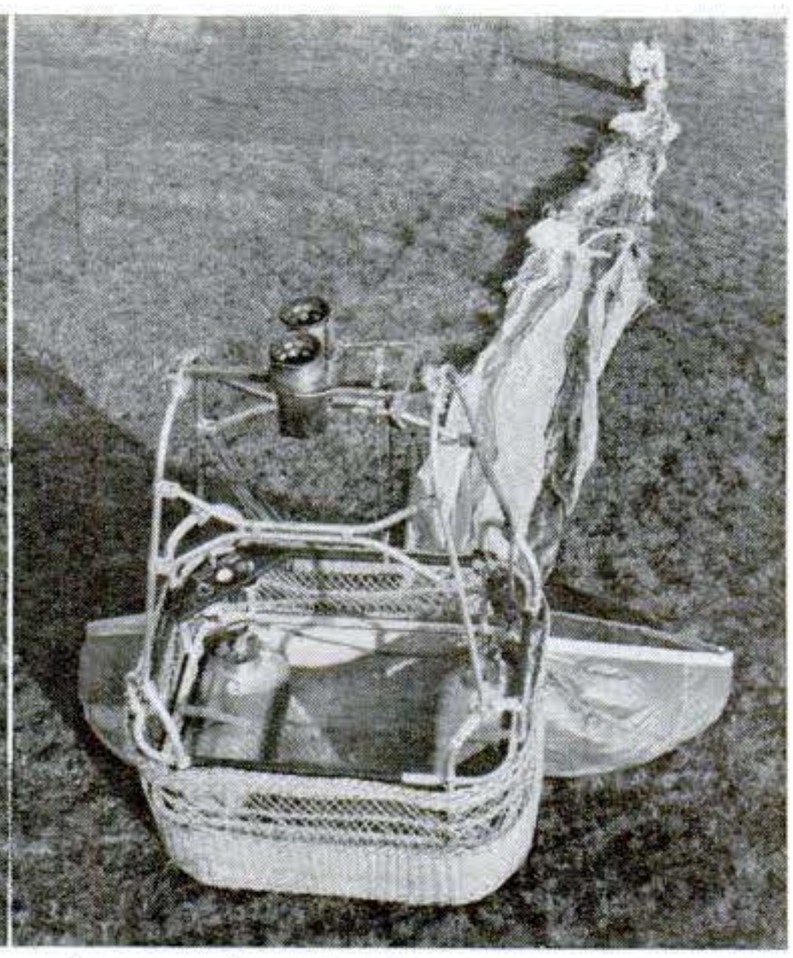
Getting High on Hot Air



Seated on a fuel tank, Hill watches the altimeter needle sweep past 10,000 feet.



All it takes to go up: (A) tubular aluminum gondola, (B) two propane fuel tanks, (C) burners, (D) inflation blower, (E) envelope in pack, (F) instrument panel.



Champing for takeoff? Inflation blower fills the balloon with air; then burners are ignited. Blower remains on ground. Total weight, minus blower—490 pounds.

By RAY HILL

PHOTOS BY OZZIE SWEET, RICHARD STAMBERG, AND BOB WALIGUNDA

"You ready?" Bob asked, looking at me. I nodded yes, and he opened the burners' blast valve. Blue flame roared up into the round 56,000-cubic-foot nylon bag above us, sounding like 100 propane torches burning simultaneously—and we lifted smoothly off the ground. I was in a Raven S-50 hot-air balloon, and the two propane burners above us were shooting out heat to the tune of four million BTUs an hour. That's equivalent to over 1,500 hp in thermal energy.

Watching Massachusetts' Palmer Metropolitan Airport shrink beneath us, balloon pilot Bob Waligunda and I stood in a small tubular-aluminum gondola between two 22-gallon fuel tanks—enough fuel for four hours. We hoped to get up to 10,000 feet and be back on the ground in half that time.

"In a hot-air balloon, you never really know where you're going until you get there," Bob said, grinning at me. That was okay with me, I told him. Any old place would do. Being at the mercy of the winds, balloonists have landed in some very odd places. Bob has logged about 600 hours in a hot-air balloon, and once even landed on a ship.

Guinea pigs with feathers. The first hot-air balloonists were a duck, a rooster—and a woolly sheep. That was back in 1783 in Paris. They went aloft for eight minutes and landed safely in a huge, but frail, linen-and-paper balloon built by the Montgolfier brothers, who started it all. A month later a man went up to 80 feet.

As ballooning progressed, hydrogen and other lighter-than-air gases replaced hot air. Straw, used for fuel to heat the air, had a dangerous tendency to send up sparks, igniting the fabric and sending the balloonist back to earth fast without his balloon.

In 1960, hot-air ballooning was reborn when Ed Yost of Sioux Falls, S.D., flew a 40-foot nylon envelope

Continued

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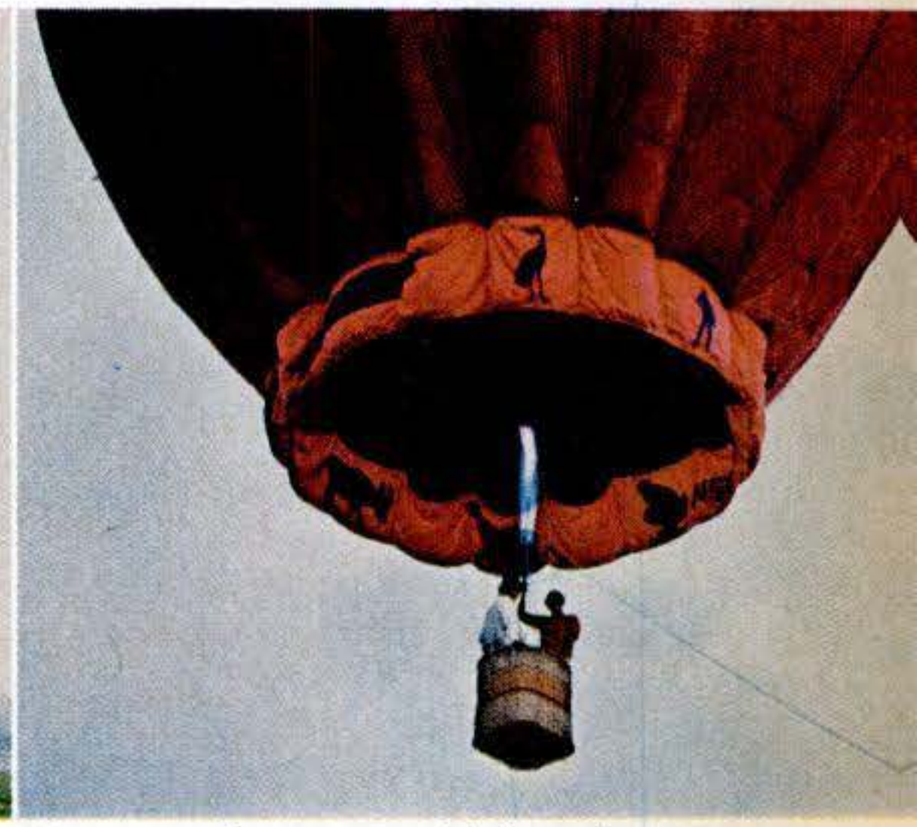
Flying over a New York aerodrome before the 10,000-foot ascent, pilot Waligunda is checked over by a restored World War I fighter.

Hot air struggling to rise inside the giant nylon envelope will soon lift the balloon upright. Nylon and dacron are the two most commonly used envelope fabrics.

Ready for liftoff, balloon is being blown sideways by wind. Inflation is difficult in winds over five mph. Winds are usually calmest in early morning and late evening.



Up, up, and away, with lifting force generated at top of the balloon. Tears or holes near the bottom of the envelope have no effect on balloon's performance.

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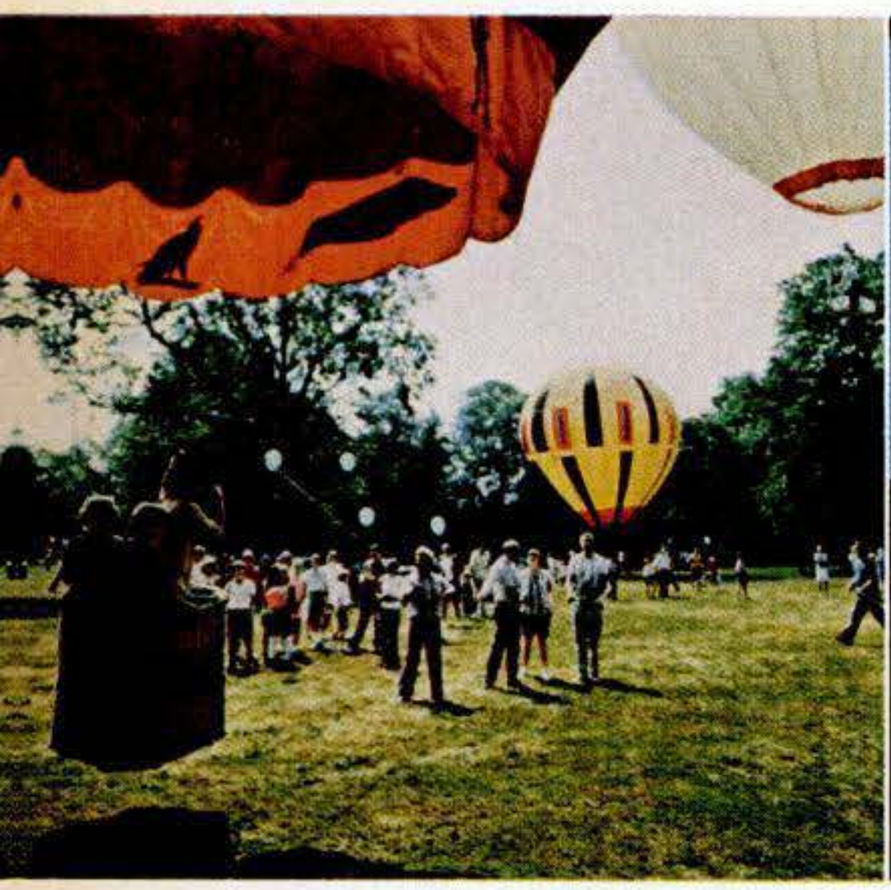
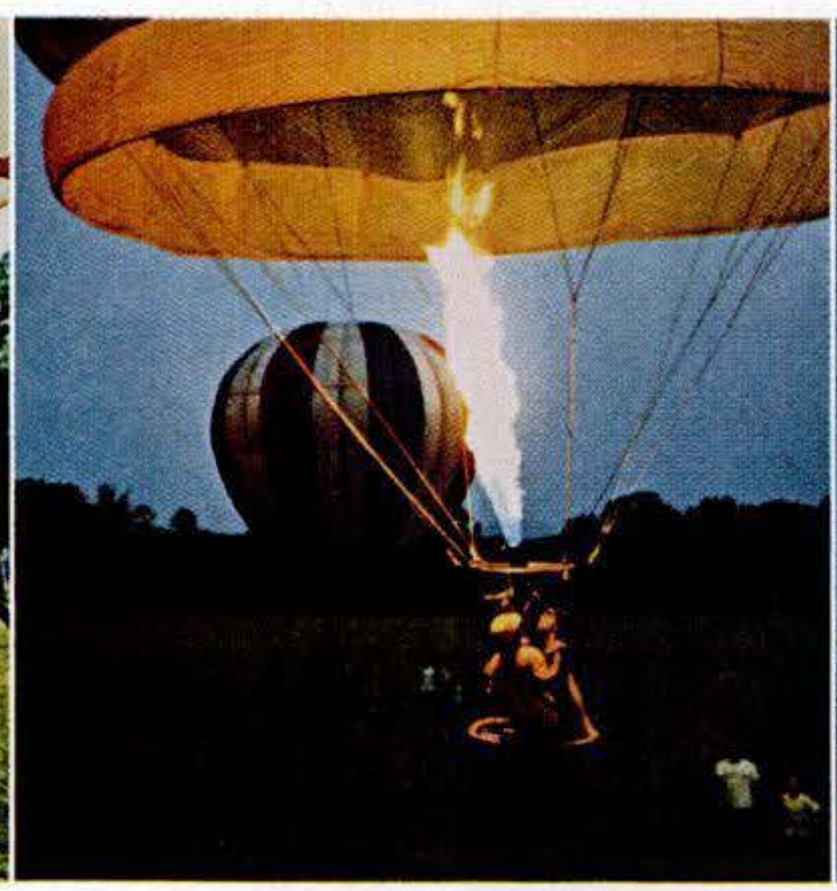
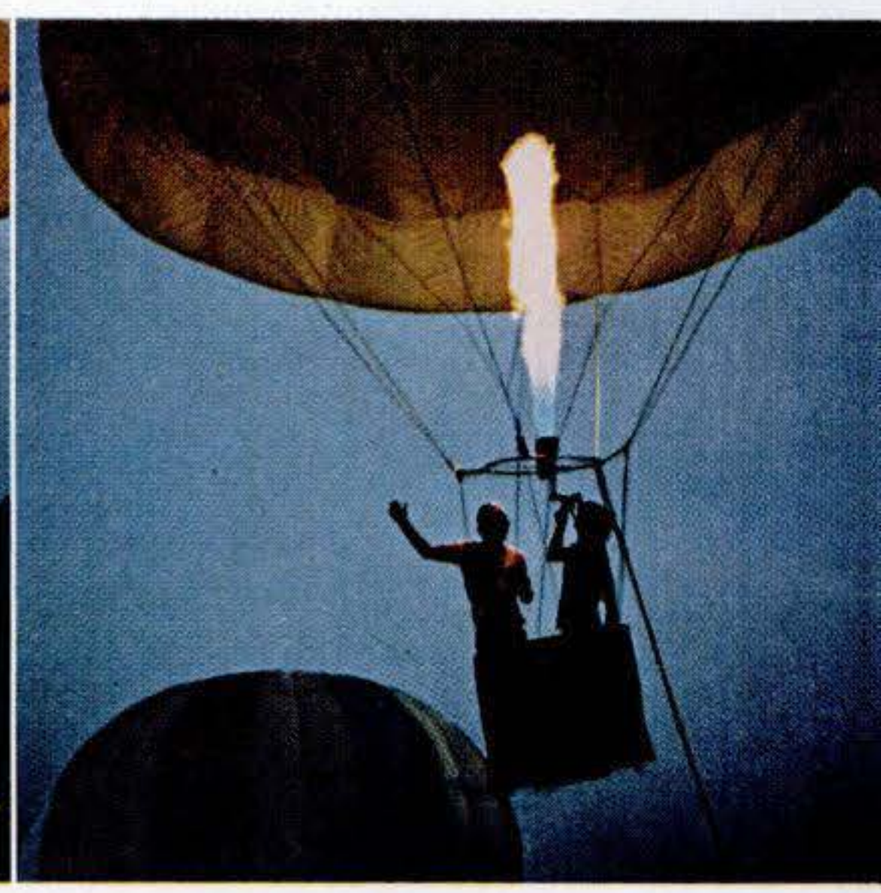
Few sights are as colorful as a group of hot-air balloons lined up to race. Unlike other racing craft, balloons have no means of forward propulsion. They can go up and down, but their forward speed depends entirely on the strength of the wind—which means the balloonist with the strongest wind behind him will cross the finish line ahead of his fellow aeronauts.



Even riding on a tether a few feet above the ground is fun. On a calm day, when the balloon is off the ground, it can easily be pulled by the tether holders.



Steel cables hold balloon envelope to wicker gondola. Author, in yellow shirt, watches flame and waits for air in balloon to warm enough to lift the gondola.



To provide lifting force, air inside the balloon envelope must be 100 degrees warmer than the outside air. Balloon can climb as fast as 1,000 feet per minute.

for 30 minutes, heating the envelope's air with a propane burner.

Since then, the demand for hot-air balloons has steadily increased and now there are three major makers and at least 12 schools across the country where you can train to become a licensed hot-air balloon pilot. A course consists of eight hours of flying, including one hour solo. During solo, you have to take one balloon away up there all by your lonesome.

Boosting yourself up. Gaining altitude is simple. Intermittently opening and closing a blast valve shoots heat up into the envelope—keeping the air at the proper temperature inside the fabric (ripstop nylon weighing 1.6 ounce per square yard).

To provide lifting force, the air inside the balloon must be at least 100 degrees warmer than the outside air. A sensor at the top of the balloon is connected to a pyrometer in the gondola for accurate temperature control. The pyrometer redlines at 275 degrees. Heating the balloon above redline can damage the fabric.

How fast can you climb? A hot-air balloon can rise as fast as a thousand feet a minute. Beyond this speed you run the risk of caving in the top of your balloon. A rate-of-

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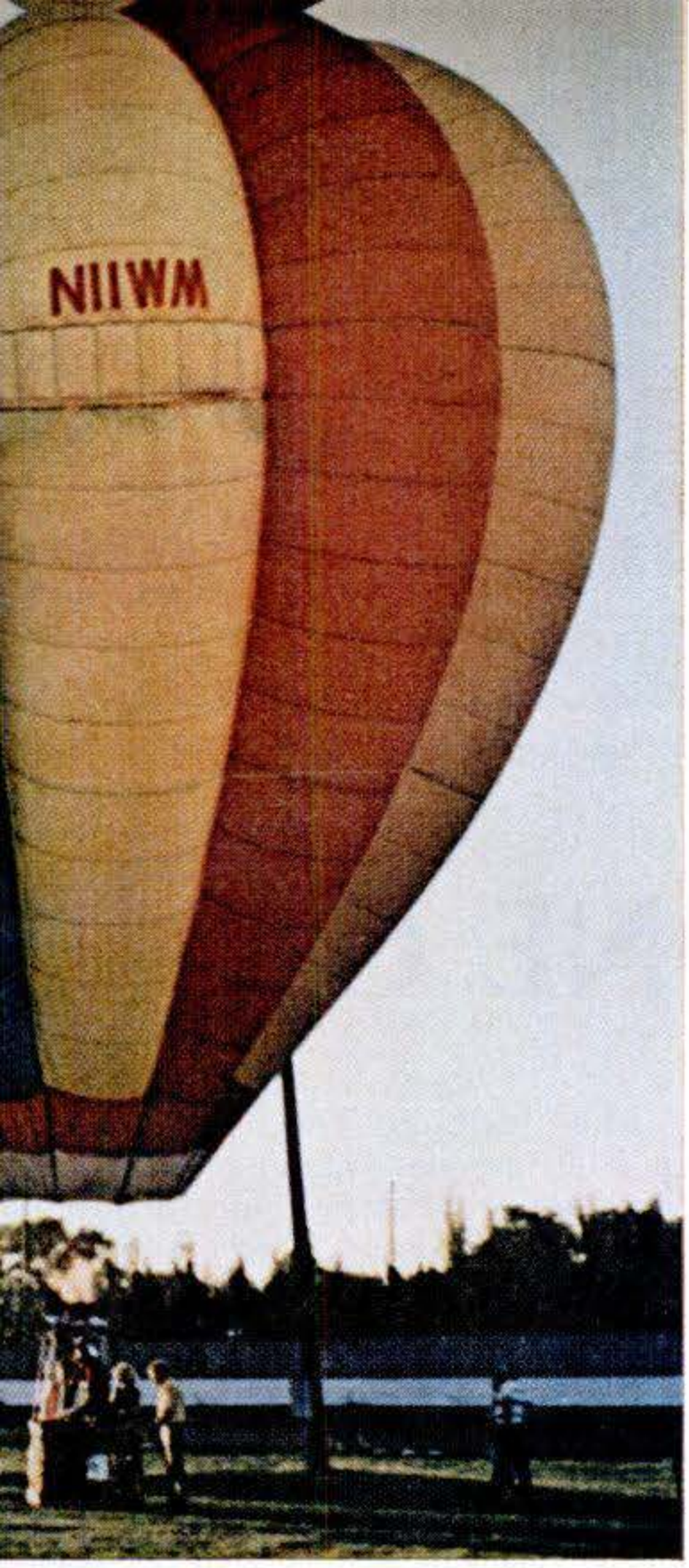

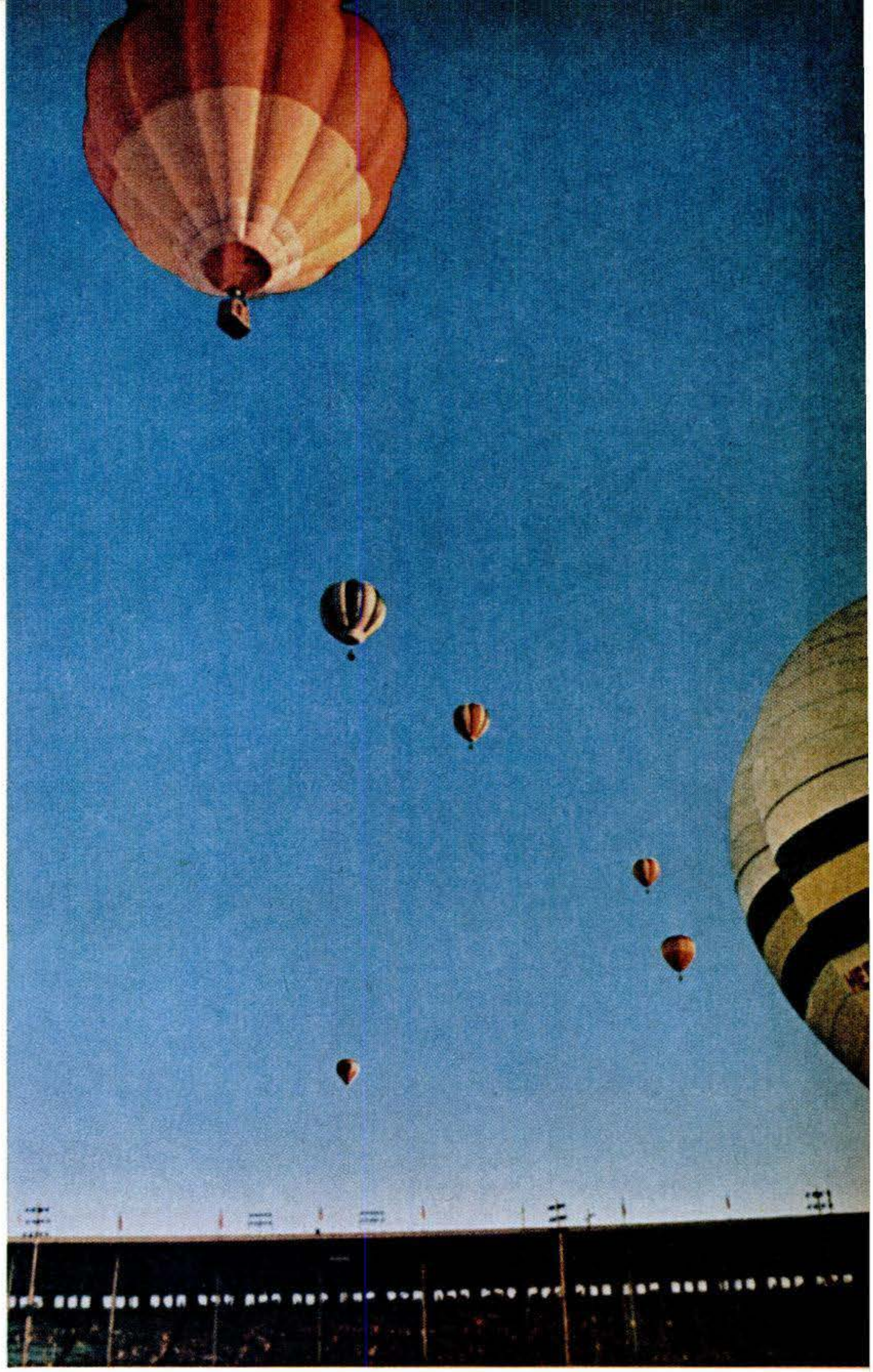

Modern balloon of lightweight nylon, using propane fuel, is far cry from first hot-air balloons—giant paper and cloth contraptions that burned straw for heat.

Balloon racing splits into three basic categories: spot landings, distance, and hare-and-hound—where the hound balloons try to follow the flight pattern of the hare balloon. Balloonists also gather for rallies—no competition here, just fun flying. You can get dates and times of races and rallies by writing Balloon Federation of America.

climb meter indicated that we were climbing at 500 feet a minute.

At 3,000 feet we went through a layer of clouds and entered a new world. Beneath us a silvery sea of white stretched as far as we could see. The balloon's shadow was on the clouds, and arcing around it was a rainbow—one of the most beautiful sights I've ever seen. A few minutes later the clouds were far below us, and the altimeter needle swept slowly past the 10,000-foot mark.

Riding the wind. We were in a wind current that Bob estimated to be 40 mph. But because we were moving with the wind, the balloon and the little 42-by-54-inch basket we were standing in were perfectly still. Far beneath us the silvery clouds were no longer an unbroken sea of white. Gaping holes revealed lakes that looked like little puddles, and great squares of land that looked like a perfectly sculpted three-dimensional color road map.

At 10,640 feet we stopped climbing and began descending—a step-by-step process. You let the air cool, then heat it again, but not quite so much, or quite so often, as when you are ascending. What happens if for

[Continued on page 118]

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This handsome marble-top card table . . . has hinged center panel you raise with a thong . . . and prop with a dowel while you choose

PS PROJECTS

SEVEN-IN-ONE GAME

It stores six gameboards under a Corian top that's ideal for most card games

By RICHARD C. SICKLER

When television palls, these long winter nights, few things are more fun than playing a game or two with your wife or (after the homework) with the kids. But searching for the desired game through drawers and closets full of leisure equipment often kills the impulse.

That's why I gathered all our favorite board games—checkers, backgammon, Scrabble, Monopoly, Parcheesi—and designed a playing table around them. The table nests the boards under its marble-like Corian top—which, in itself, makes a fine playing surface for card games, or just for serving refreshments. Two drawers keep all the playing pieces at hand. When the urge for a game strikes, you just pull a rawhide thong to tip up the hinged nest, shuffle through the stack of boards (mounted back to back), place the one you want on top, and drop the stack back into the top frame.

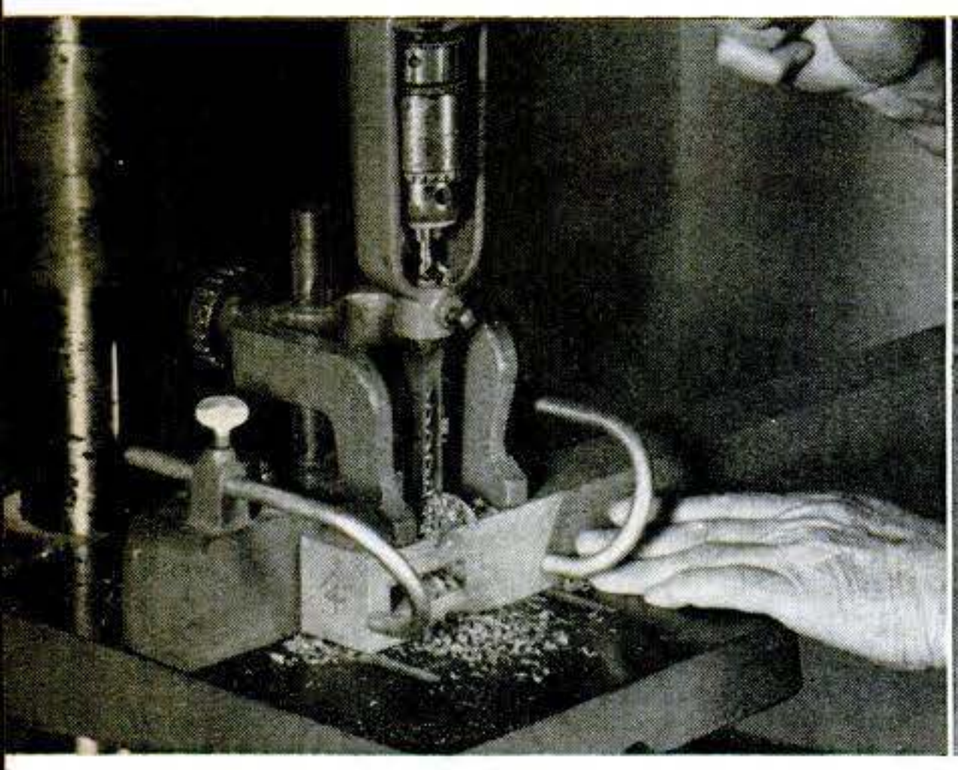
And a bonus. You get a table so handsome and useful you'll want it on permanent display in the living room —a reminder that fun is always handy.

You'll probably choose a wood that matches your present furniture—maple, walnut, oak, or pine. If not, do as I did—use Philippine mahogany, filled and stained a rich brown to accent the grain. And trim it with delicate brass highlights, such as square rod tapped into routed grooves with a rubber mallet.

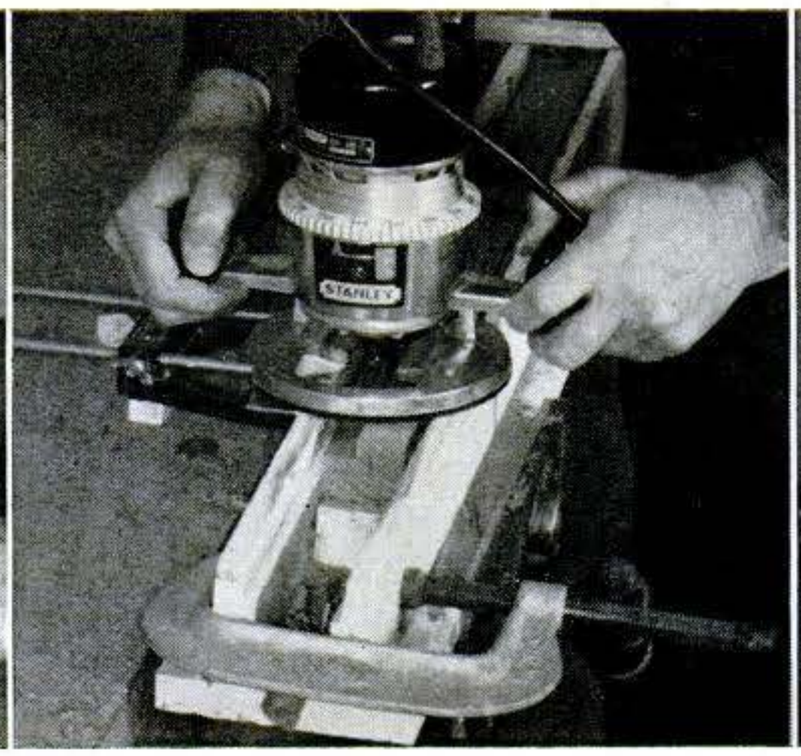
Turn the page to study the construction drawings. You'll note that the table isn't difficult to build, though the power tools and jigs shown in the photos below will speed the work considerably.

How it's built. The understructure is fairly simple. Openings for the two drawers are cut in opposite aprons with a saber saw. Two slats across the center support the gameboard nest and serve as guides for the drawers. (Ten cleats of varying dimensions are screwed to the inner faces of the slats for these purposes.) A square of 3/8" plywood makes a floor for the gameboard nest, and is hinged to one of the slats. At the opposite side, a rawhide thong is anchored to the underside of the plywood. Enough wood is removed (from cleat, floor, and slat) to create a channel that lets the thong move freely up through the stack of gameboards.

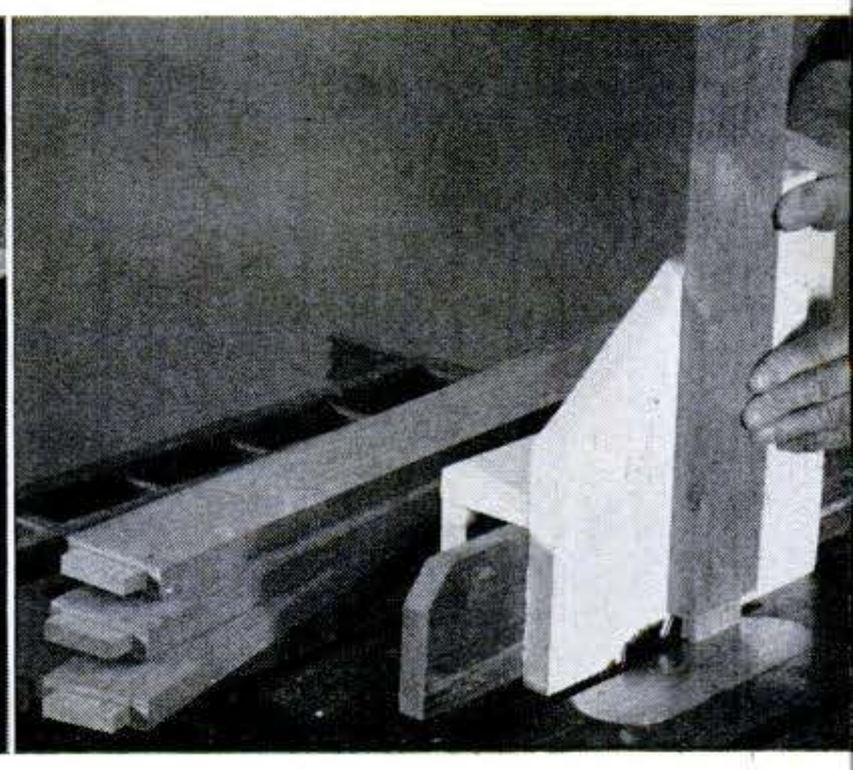
Screws through corner blocks secure the top to the understructure. The finish on a game table should resist water and alcohol spills, plus the foods and juices that usually accompany family fun. I first used a dark mahogany penetrating-stain filler. After it had dried for 48 hours I applied a penetrating resin varnish.



Mortise four legs before you taper them. While this can be done with hand tools, mortising attachment on your drill press does the job much faster, more uniformly.



Cut tapers on both inside edges of each leg, using a tapering jig and a router—or table saw. Plans for such a jig are in most instruction books for these tools.



Accurate tenons require a simple tenoning jig that rides on the rip fence of your table saw. Again, you'll find plans for this jig in nearly all books on this tool.

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which gameboard you want for playing.

TABLE

With this type of varnish, you brush it on, let it stand for about an hour, then wipe the excess off the surface. Three or four coats are best. The result: a satiny, hard, rubbed finish that brings out the grain of the wood and will wear and wear. One of the best brands is Tungseal Danish penetrating varnish. You'll find it at most good paint and hardware stores.

Sources of supply. To obtain the other materials:

- Corian is, of course, DuPont's methacrylate panel, with subtle veining in your choice of gray, green, or beige. It comes in ¼" and ¾" slabs. You may be lucky enough to find a building-supply dealer who will sell you a piece of ¼" scrap from which you can cut the 18" square you'll need. If not, you'll find many project uses for the rest of a full sheet—such as the picture frame and glow lamp we presented in last month's Winter Workshop section.

If you have trouble finding Corian, write Building Products Div., DuPont & Co., Wilmington, Dela. 19898. For tips on working with the stuff, see our March, 1971, issue.

- Brass leg sockets (No. R-12, with 1"-square openings) can be ordered from Period Furniture Hardware Co., 123 Charles St., Boston 02114.
- For the trim, you'll need 24 ft. of ⅛"-square brass rod cut into three-ft. lengths—plus four ½"-dia. brass knobs. If you can't buy this locally, write Simon's Hardware Inc., 421 Third Ave., New York 10016.
- The games you may already have. If you want additional boards to complete a set of six, you'll find them at variety or department stores. Parker Bros. and Selchow & Righter offer the best selections of old favorites and modern classics.

Mounting the gameboards. Boards for Monopoly, Parcheesi, and some other games are larger than the 18"-square nest provided here. The actual playing area of all popular games is within these dimensions, however, and you can easily trim down the borders. Use a fine-tooth plywood blade on your table saw. Mount two of these trimmed-down boards back-to-back, taking care to place center folds at

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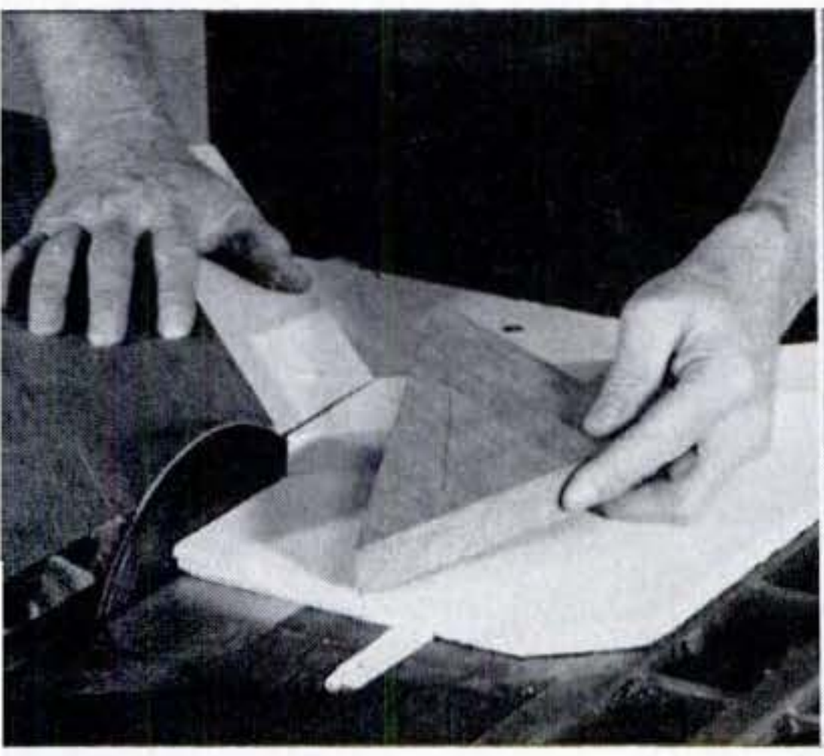
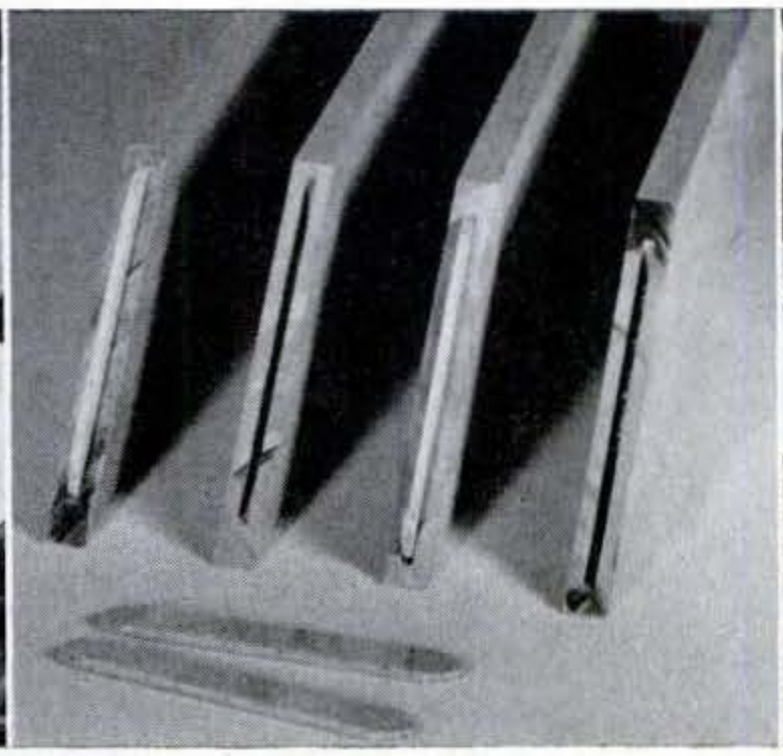
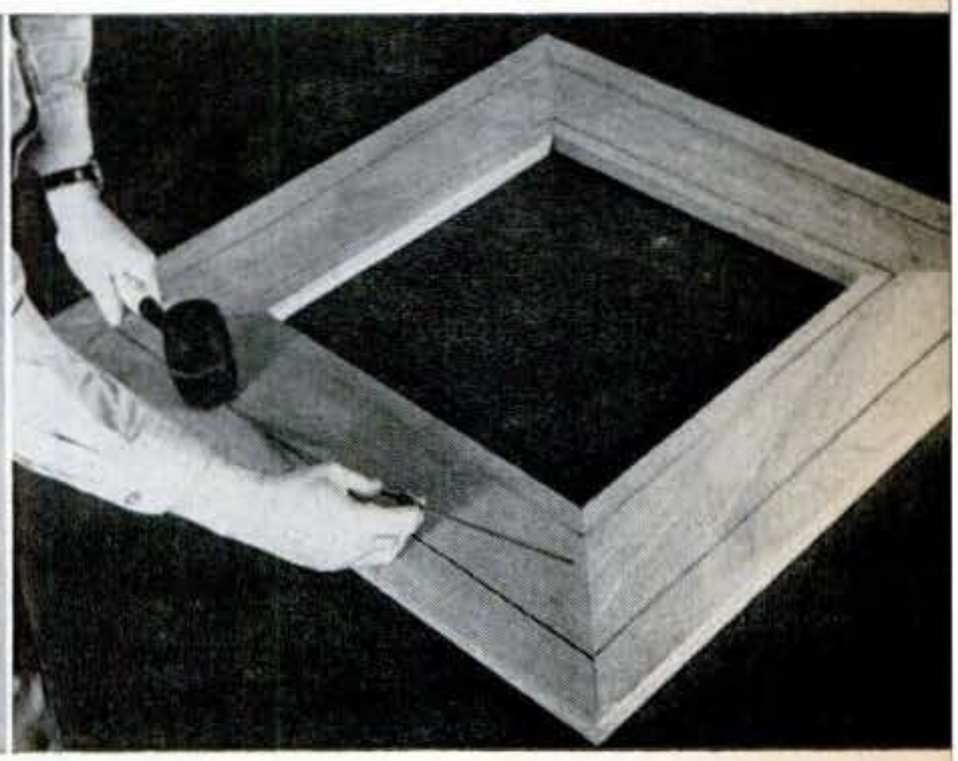


Another simple jig makes mitering easier. The corner angles for the table top are critical, so a jig that rides in the saw-table grooves (and permits no creep) is essential.



Cut spline grooves into the mitered edges of the top boards, using a dado cutter. Grooves above are ¼" wide and ¾" deep to take 1⅜"-by-7½" plywood splines.



Plow channels for ⅛"-square brass, using a veining bit in your router, after assembly of top. Grind 45-degree miters on ends of each strip, force in place with mallet.

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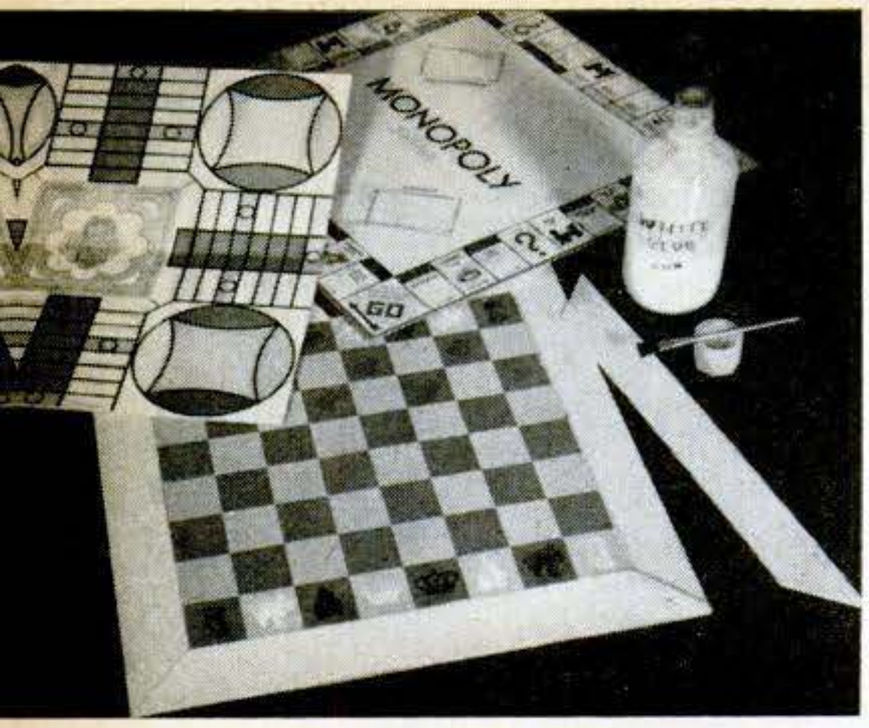
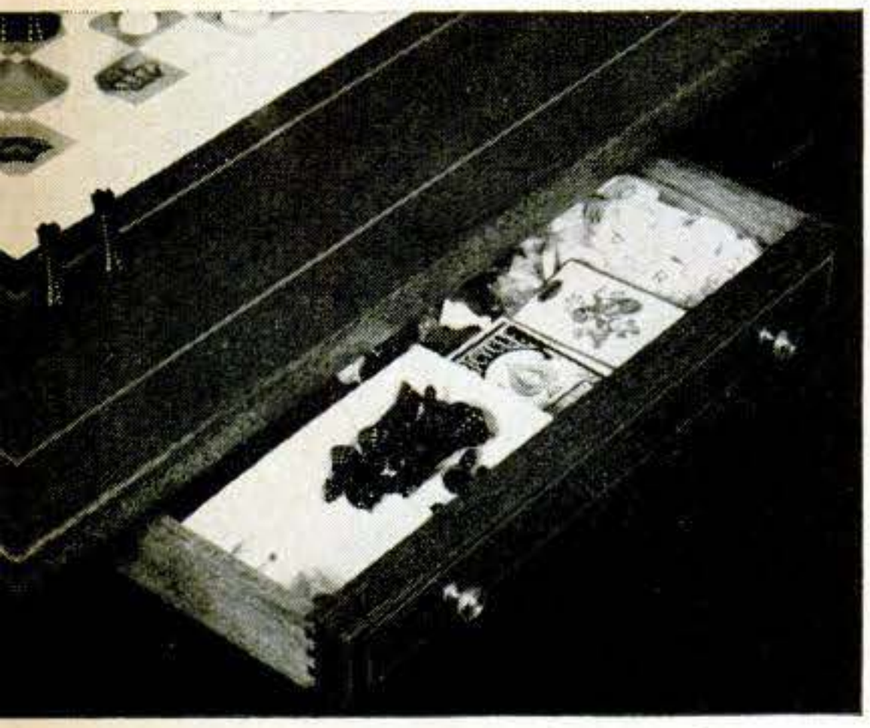


Size of standard gameboards varies from 15″ to 20″. Tabletop nest is 18″ sq., so mount smaller boards on ⅛″ plywood and frame with mitered veneer strips as above.



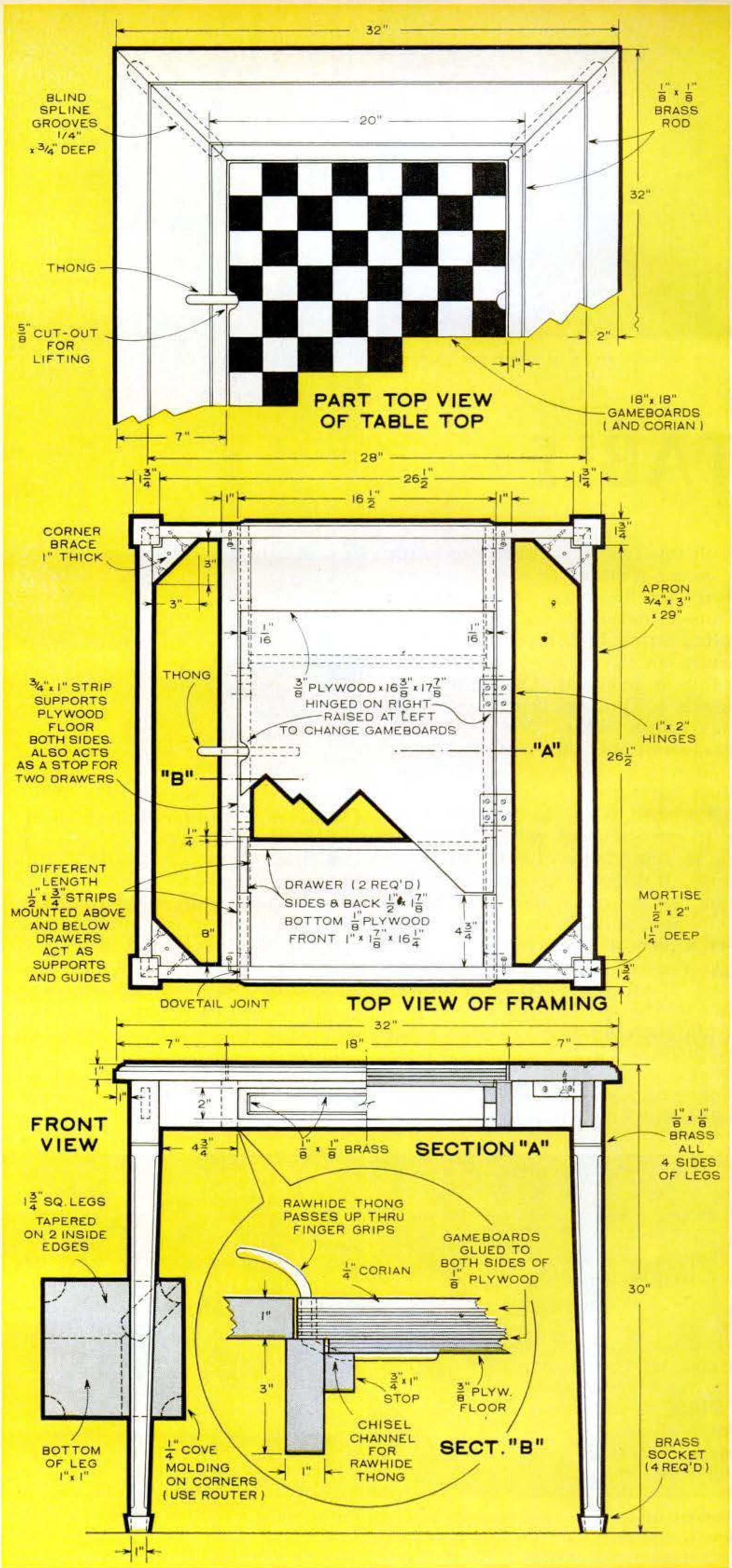
Drawers on opposite sides of table store all accessories for games nested in top. Fronts are dovetailed and trimmed with brass to match top. Add two brass knobs.

right angles. Tape edges with an appropriate color of cloth mending tape for smooth, strong edges.

When the board size is *smaller* than the 18″ nest (like the checkerboard in the top photo), glue it to a stiff backing that's been cut to the nest size, and frame it with mitered strips as shown. For backing, I used ⅛″-thick three-ply poplar. Framing strips should be as thick as the gameboard. Usually, the same ⅛″ plywood works fine.

Though white glue will do both of these mounting jobs, you may prefer the instant adhesion of contact cement. For durability, brush a coat or two of clear varnish or lacquer over the face of each game. Let dry thoroughly before stacking in the table recess. Note that there's a finger hole at two sides of each board for easy removal. Always stack the boards so that these align.

You may wish to partition both drawers to keep markers, dice, decks of cards, and other playing paraphernalia neatly compartmentalized— especially since the table will be frequently moved. Strips of the ⅛″ plywood, slotted for egg-crate assembly, will do the job. PS



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Glaring menacingly at a telemeter transmitter like the water-sealed unit strapped to its back, huge blue crab is readied for tests.

Keeping Tabs on NASA's Crabs

Space technology goes underwater for unique tests on an ocean food source

By JOHN R. FREE

How do you "wire up" a blue crab to find out what polluted water does to it? This large crustacean found in ocean estuaries is an important multi-million-dollar food source.

The Bureau of Fisheries turned to NASA's microelectronics and telemetering experts for the answer. As a result, the lowly crab joins a growing list of animals—elephants, bear, elk, penguins—"bugged" by scientists to monitor their environment, living, and migration patterns.

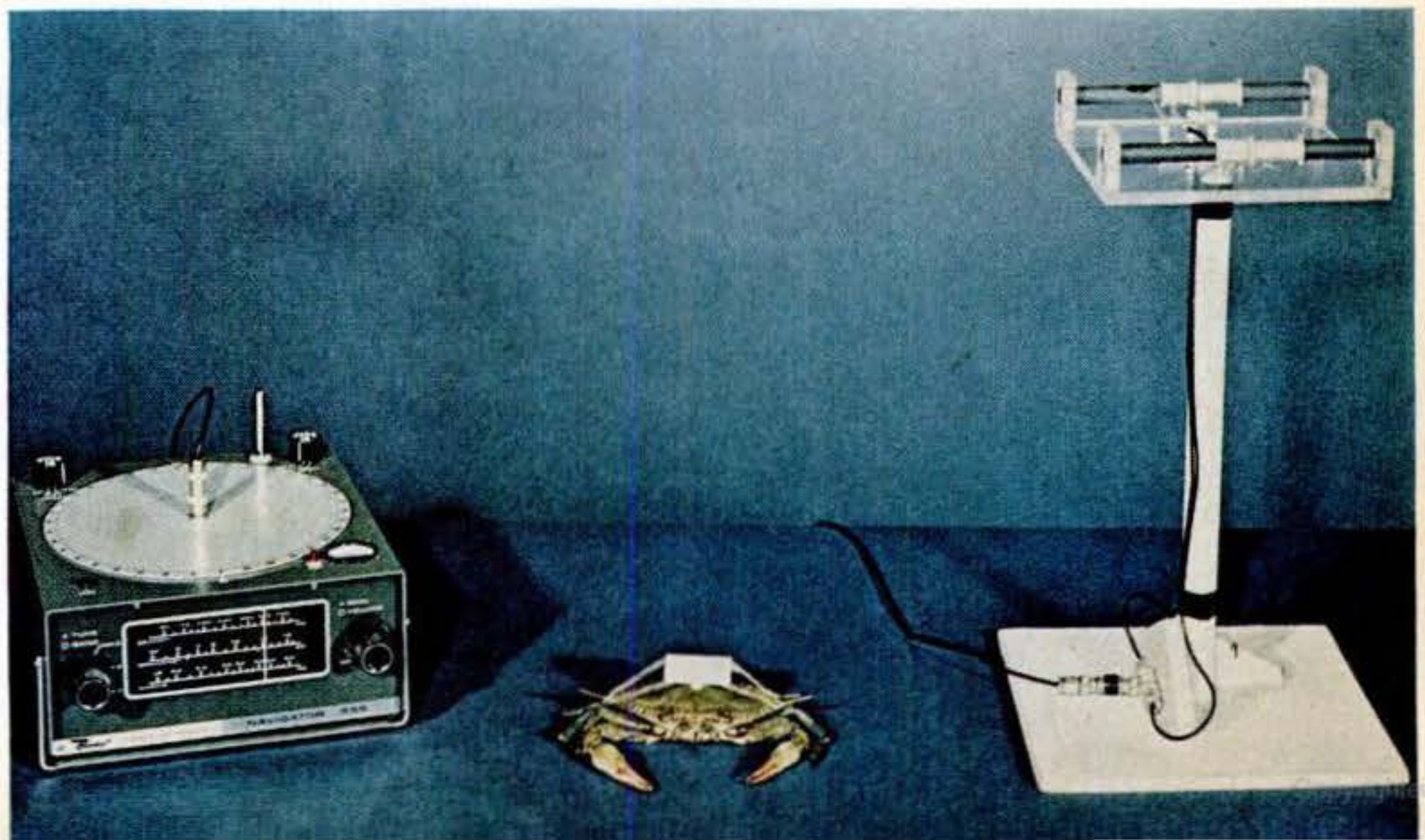
NASA's miniaturization wizards dreamed up a unique package that keeps tabs on a crab's internal ion concentration. This technique monitors osmo-regulatory changes—how a crab regulates internal fluids as water conditions change.

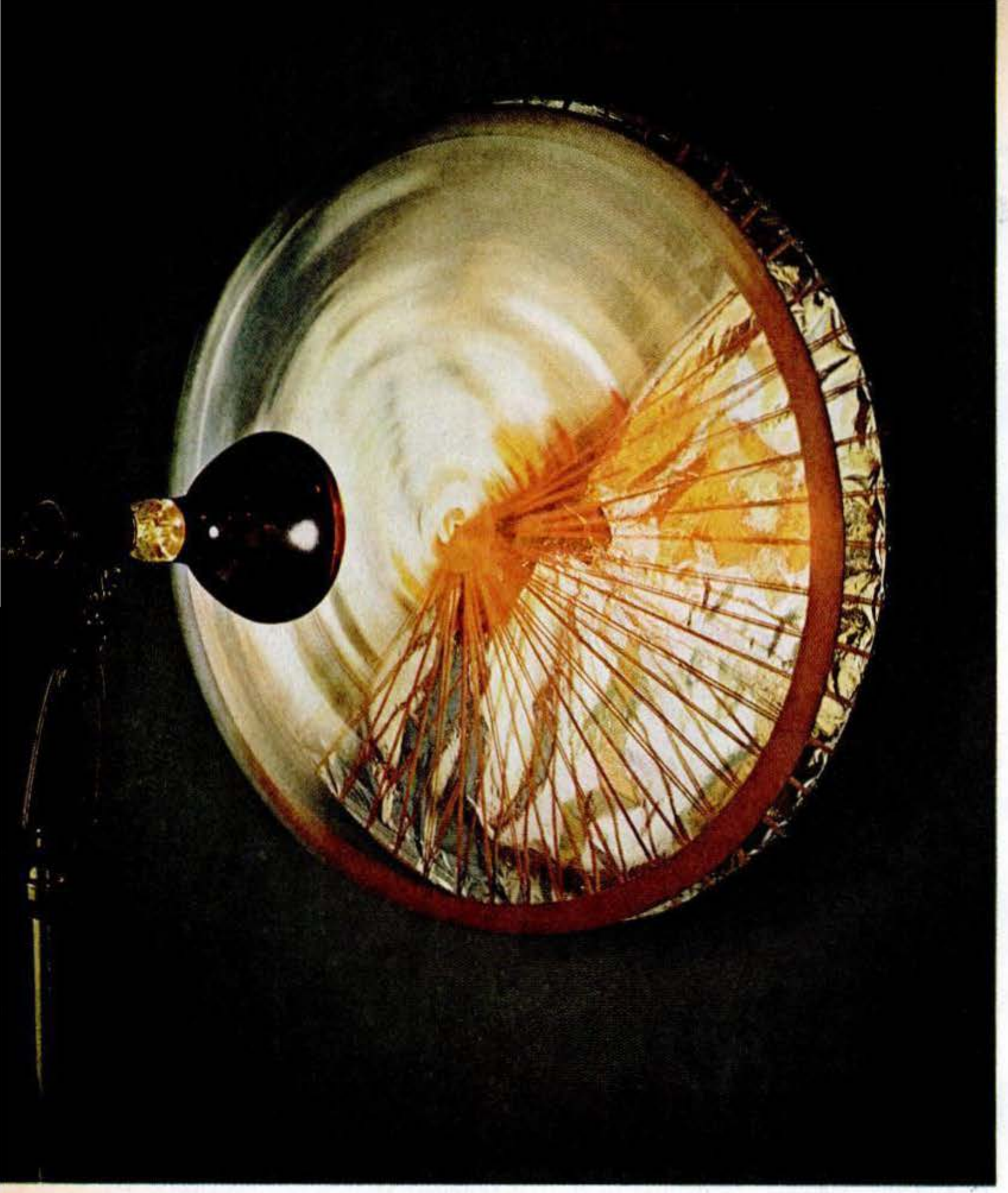
A tiny ion-sensitive probe is implanted through a hole drilled in its shell; a sealant prevents water leakage into the crab. Ion readings—along with heart-beat data—are radioed from a matchbox-size transmitter attached to the crab.

The telemetered data can travel only short distances in salt water, so crabs are kept in three-foot-square cages at various locations in shallow estuaries. Data is transmitted to some point on or outside the cages.

The blue crabs, described as rather aggressive and active, will eventually have their electronic leashes lengthened, letting them scuttle about more. Meantime, a steady stream of data is accumulating on charts to indicate one way we're influencing our ocean food supplies. PS

Radioing signals that can show its internal chemical responses to changing water conditions, a blue crab is flanked by a receiving antenna (right), and signal decoding system (left). Antenna must be near underwater cage, since water attenuates RF.





Heat Runs

You can build this proof of a surprising fact: Rubber contracts when heated

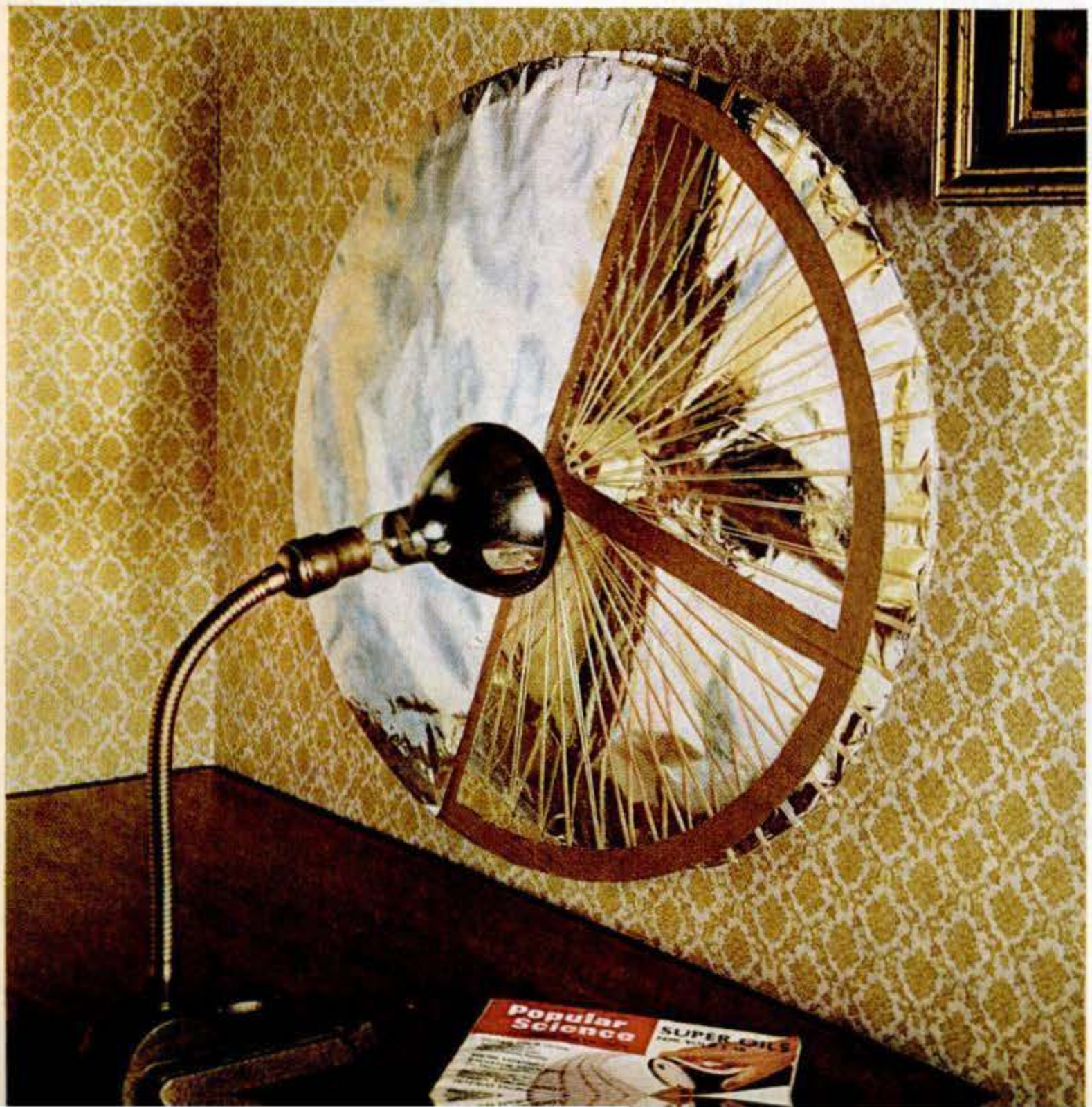
By RUDY KOUHOUPT

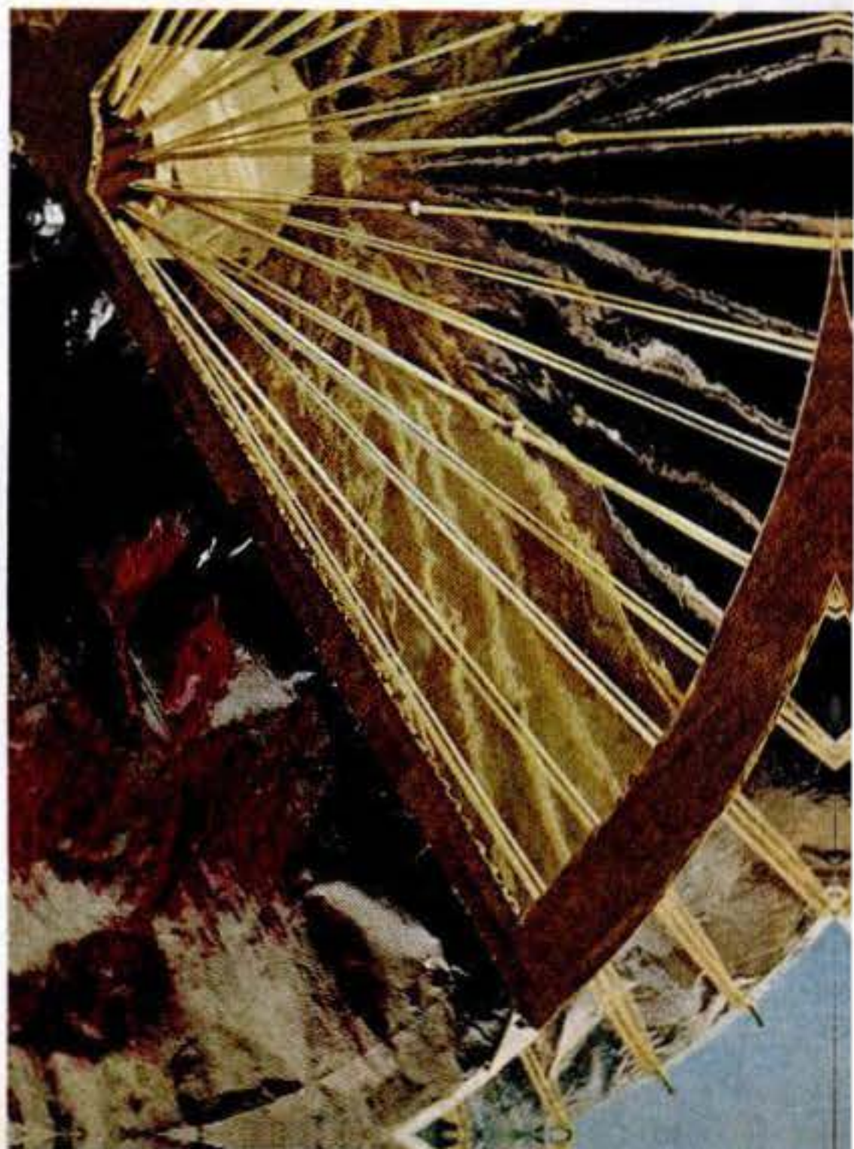
What happens when you heat up a piece of rubber that is stretched out and under tension?

If you said it expands like most everything else, you were wrong. A stretched piece of rubber *contracts* when heated. In doing so, it exerts a measurable increase in its pull. This surprising property of rubber was first observed by James Prescott Joule about a hundred years ago and is known as the Joule effect.

Shown in these pages is a small engine that takes advantage of this fascinating property of rubber.

Infrared heat lamp provides radiant energy for slow-speed operation of Joule-effect engine in color photo at upper left. Bulb is a 250-watter placed less than a foot away to shine on the entire circumference of engine. Speed of any such engine is limited by time needed for the shaded rubber to cool —and expand to its normal dimensions. In photo at lower left you see how you might set up the engine as an exhibit. Hang it on the wall behind your desk and place heat lamp in a gooseneck. Only trouble: The stretched rubber develops a "set" during idle time, and you'll have to balance the engine again by knotting a few of the rubber bands on the weaker side (photo below).





Amazing Rubber-Band Motor

The diagram on this page shows how this small Joule-effect engine works. While it doesn't develop a lot of power, it helps demonstrate what you might expect from a much larger model—responding silently to a radiant-energy source like the sun, doing a practical job such as driving an electric generator.

How much power? This is determined by a number of factors. Most basic: The more rubber in the field, the greater the potential power.

Also, the Joule effect is most marked when tension on the rubber is greatest. However, excessive stretching weakens the rubber. So for practical work it should not be stretched to more than three or four times its normal length.

The stronger the source of radiant energy, the faster the engine will run —and the more power it will develop. The rubber cools off more slowly than it heats up, so the practical limit is likely to be set by the cooling phase of the cycle.

The demonstration engine ran at about 180 revolutions per hour, or three rpm, with a 625-watt parabolic heat lamp about 11″ across, the kind often found in a home. (Sears catalog lists a 660-watt heater of this type, 34 G 7166, for $5.95.) Heat from the 250-watt infrared bulb shown in the photos runs the engine at a lesser speed—only about one rpm.

Beginning construction. Start by cutting a 24″ disk of ¼″ plywood to make the engine frame. Use a tape measure to measure the circumference of the circle, and mark off 54 equal divisions along the edge. Drive a small nail into the edge on each mark, leaving part of the nail sticking out to hold the rubber bands.

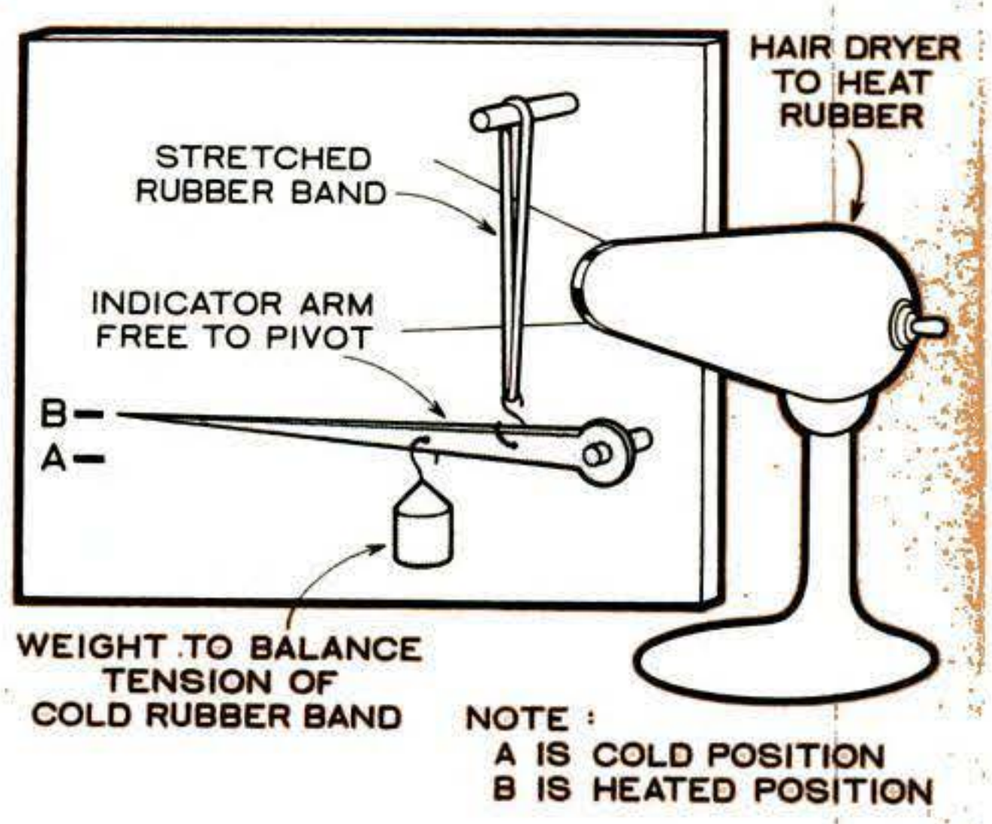
Cover the top surface of the engine frame with household aluminum foil. This will act as a reflector for more-uniform heating of the exposed rubber bands. Bend the foil over the edge of the frame between nails and staple it to the underside. Use cardboard strips to reinforce the foil where it's stapled.

Cut the bearing block from wood. Drill a 3/16″ hole through the center to clear the crankshaft. Counterbore the crankshaft hole from top and bottom to take ball-bearing sets.

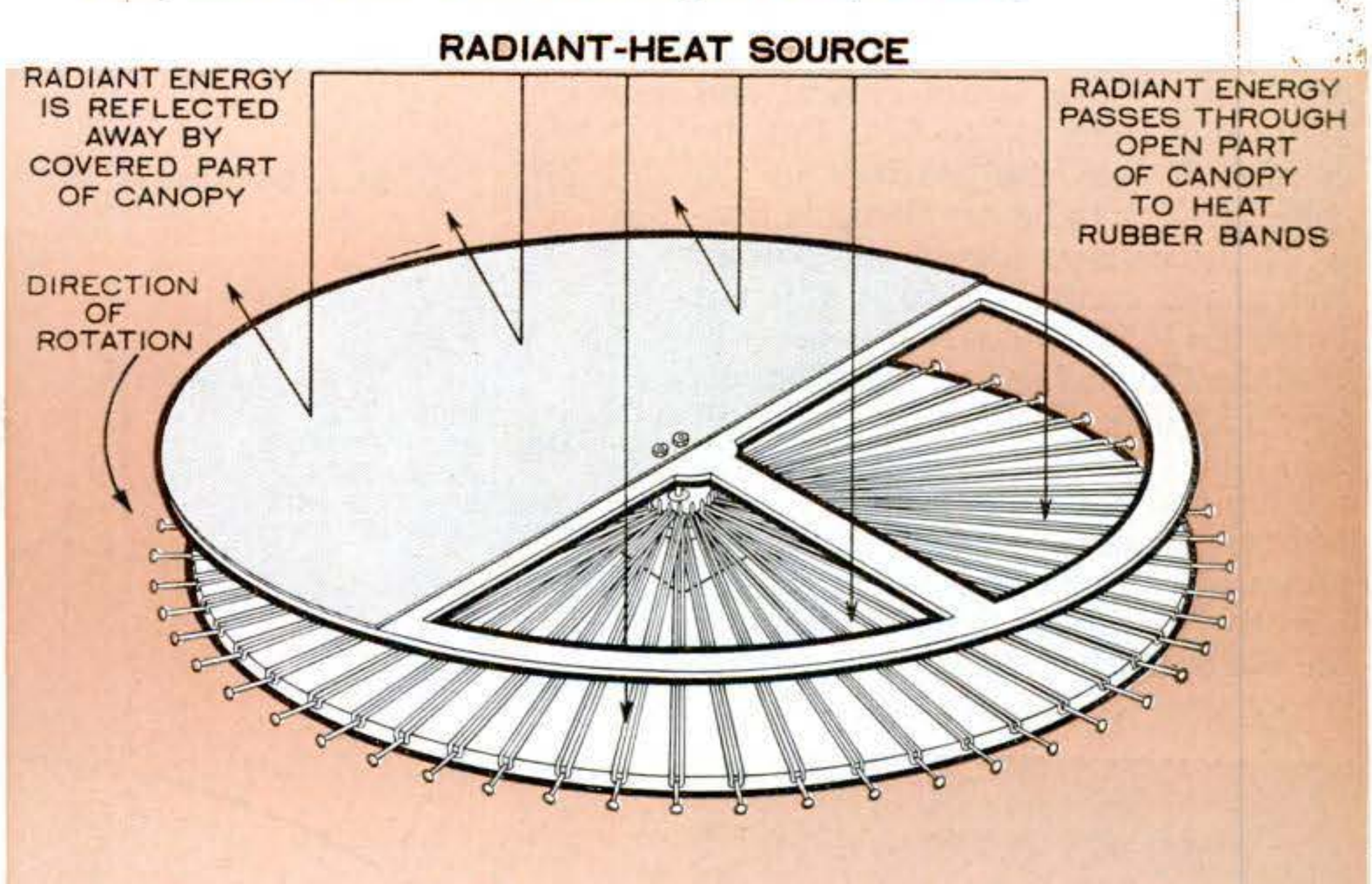
Continued

Simple exhibit demonstrates Joule effect

You can set up your own demonstration of the fascinating discovery made about 100 years ago by a British physicist, James Prescott Joule—that a length of stretched rubber tends to contract if heated, not expand as you might expect. Place your exhibit on a small sheet of plywood or hardboard. Heat rubber band with a hair dryer and it will contract, pulling indicator up to B. Let the rubber cool and the indicator will drop down again to position A. Engine below puts the principle to work.



How the Joule-effect engine operates



Joule-effect engine you build operates as shown in the diagram above when it is subjected to a radiant-heat source. Radiant energy passes through the open part of the canopy, striking part of the stretched rubber bands and heating them. The others are shadowed by the covered part of the canopy, which reflects the radiant energy away. As the exposed rubber bands are heated, they undergo the Joule effect. This causes them to contract and pull against the crank, forcing it to rotate toward the heated side. The canopy attached to crank swings around, exposing cool rubber bands to the heating effect of the radiant energy and shadowing some heated bands—which then cool off. Upon cooling, bands expand to their original condition. Since the canopy and crank move together, the process is self-sustaining and keeps the crank rotating as long as sufficient radiant energy is available to heat the exposed rubber bands. Since Joule made his discovery, many scientists have made working engines using the principle. Will a practical engine ever result—one that can do useful everyday work? This is an area of research for the future.

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Canopy must be carefully balanced. Knitting needle through center makes a good axle for doing this. Press small nails into edge of corrugated cardboard to balance.

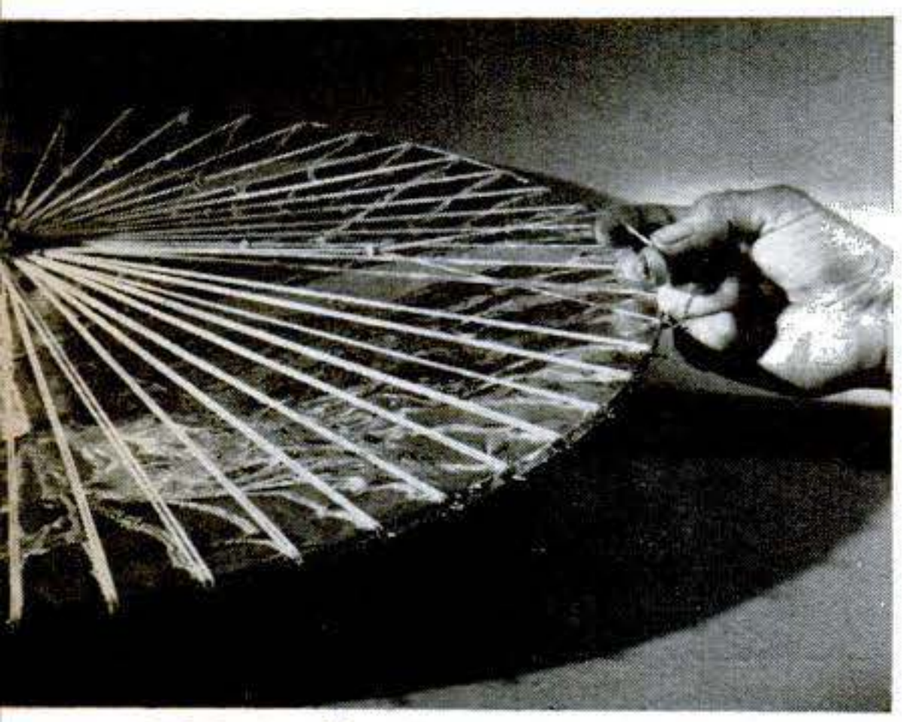
Suitable bearings can be obtained from Chicago Gear Works, 440-450 N. Oakley Blvd., Chicago 60612. Ask about Series B annular bearings (Catalog G-75). You will need three units. Total cost delivered to you is $1.90 for each bearing. They may vary from mine in overall size, but the 1/8" bore is the only critical dimension.

Fasten the bearing block to the engine frame with two wood screws through holes drilled in the bearing block. Locate the bearing block so that the crankshaft hole is exactly centered on the 24" engine frame.

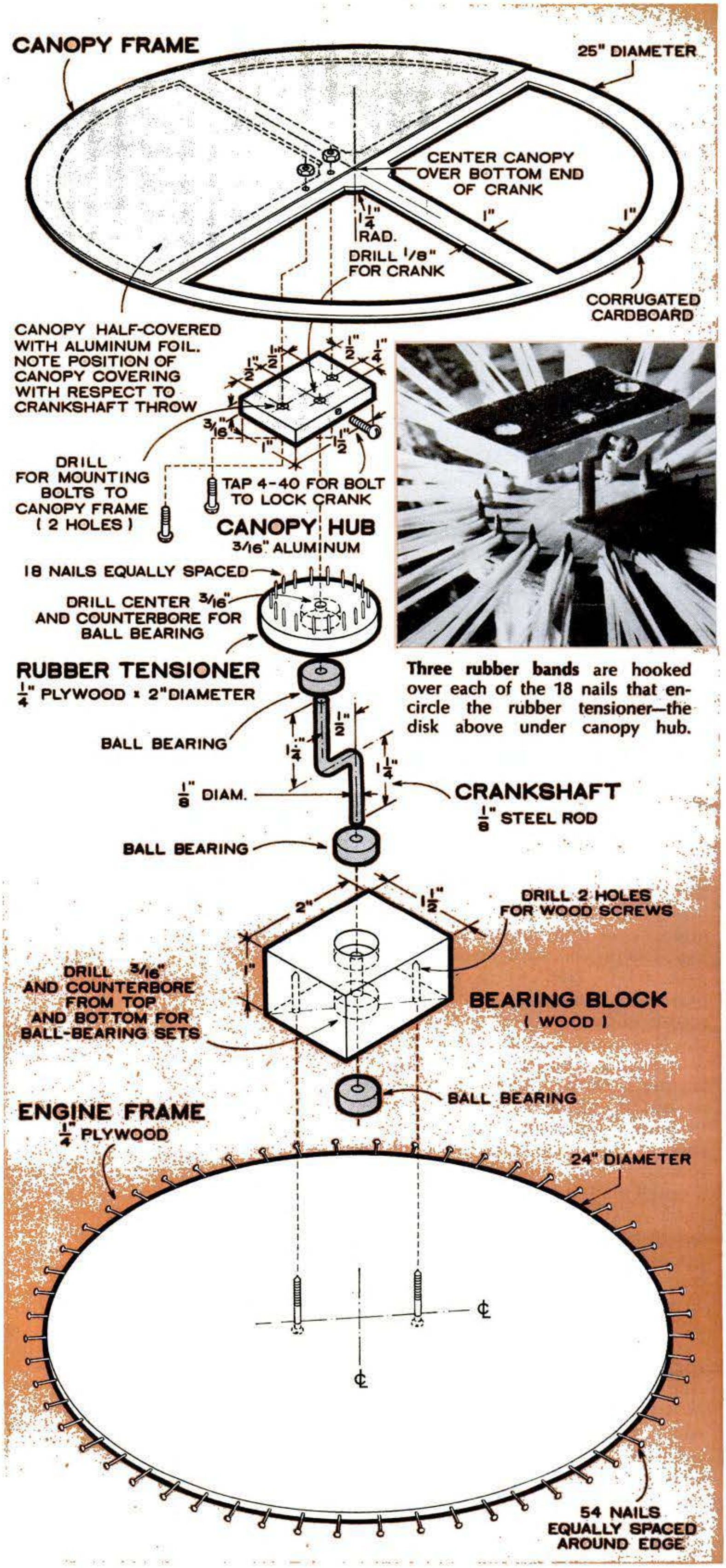
Bend the crankshaft. Use a 3" length of 1/8" rod. The length of the crankshaft throw is not critical and may range from 3/8" to 5/8". Put the crankshaft into the bearings in the bearing block to be sure it turns freely. If necessary, cut off the bottom end of the crankshaft so it will not touch the 1/4" plywood.

Make the rubber tensioner by cutting a 2" disk of 1/4" plywood. Drill a 3/16" hole through the center to clear the top end of the crankshaft. Counterbore about 3/16" deep from the underside so you can put in a ball-bearing set. Check the piece in place on the crankshaft to be sure it does

[Continued on page 129]



Field of rubber bands must be kept in balance if engine is to work properly. Do this, as explained in the text, by removing some of the bands and tying knots into them.



Three rubber bands are hooked over each of the 18 nails that encircle the rubber tensioner—the disk above under canopy hub.

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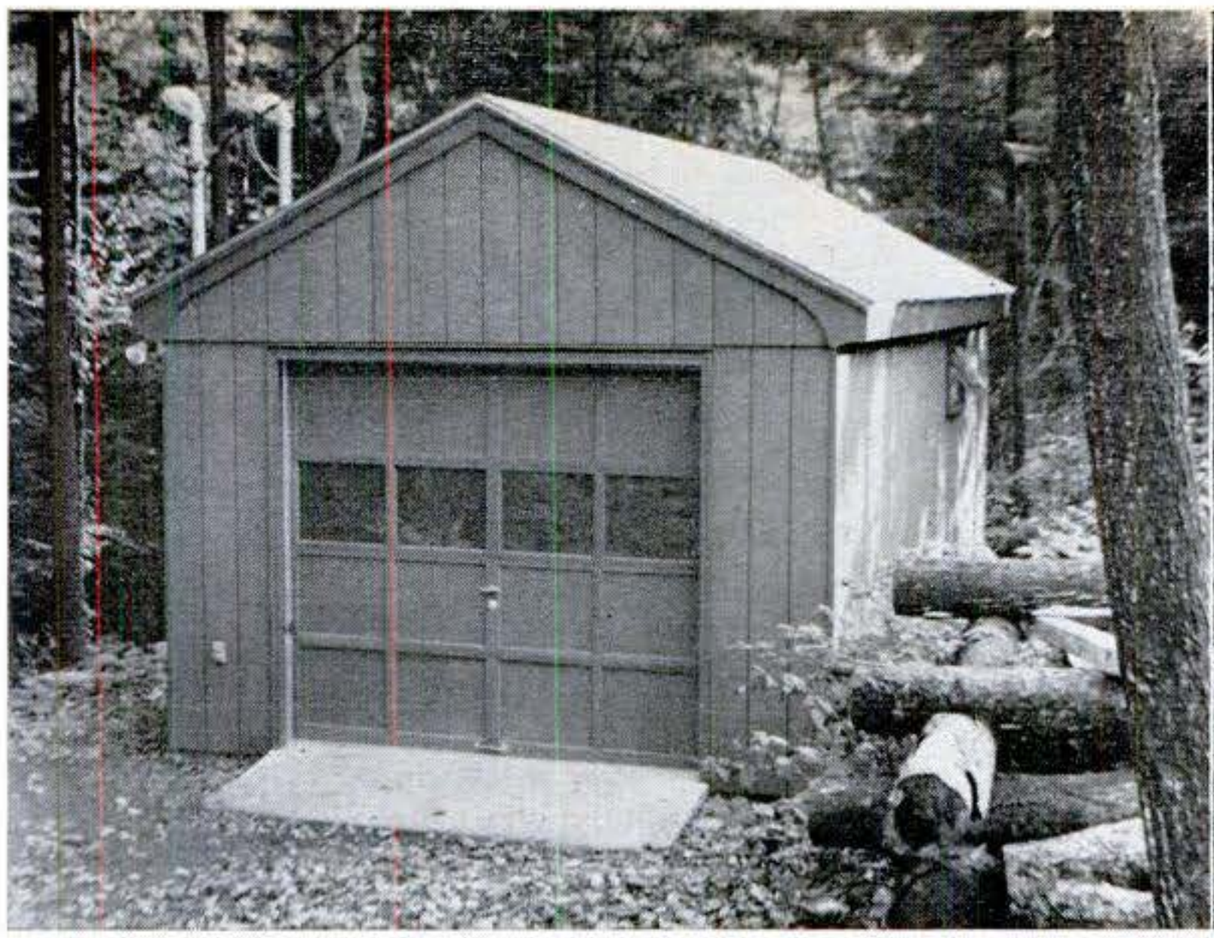


Handsome as it is sturdy, this 12'-by-22' garage was erected in two weeks from materials that arrived as single load (right).

It's all here—down to last nail—loaded at the yard from a standard checklist. You supply the slab and anchor bolts (foreground).

PERSONAL-USE REPORT

You can erect this "KIT" GARAGE

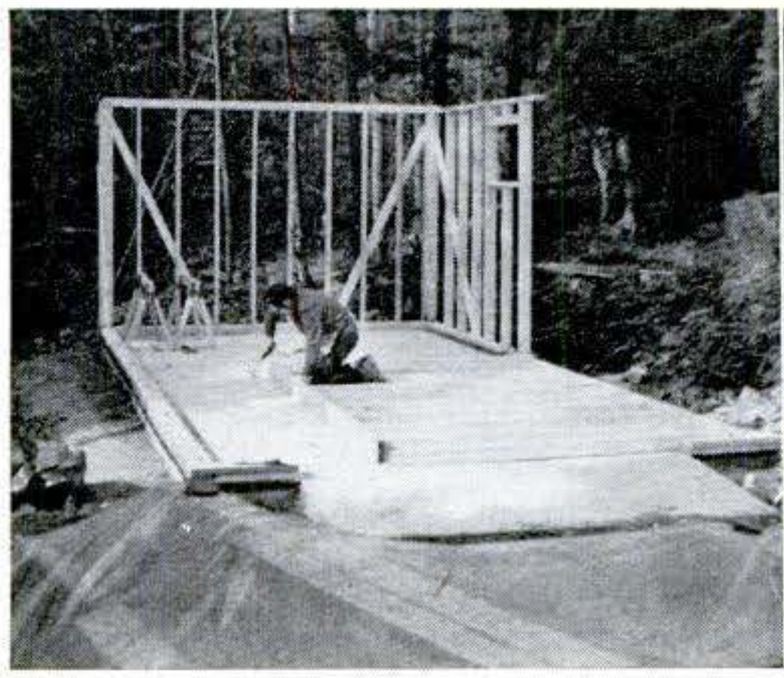
By AL LEES / *Home Workshop Editor*

Quickest, cheapest way to a new garage? It's the "package deal" offered by many lumberyard chains. I erected this model in the mountains, and can endorse the concept.

Everything you need to complete construction arrives on one truck—and I mean everything: framing lumber, plywood siding, asphalt shingles, window units, overhead door (complete with key lock)—even a supply of each type of nail you'll require.

Nothing is prefabbed or precut. What you get is the raw material to build exactly the garage shown on the pretested plans. These plans arrive with the same truck—but I'd recommend trying for an advance set. You'll want their recommendations for the concrete slab and anchor bolts you must provide; and preparatory study of the plans will pay dividends when you start to build.

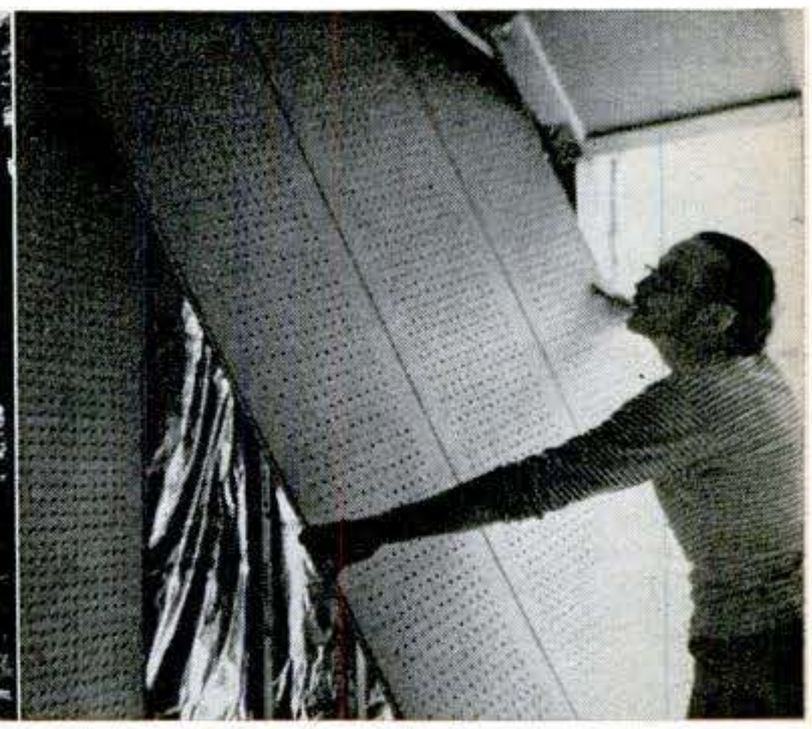
Not that the plans are difficult—they're based on standard framing techniques. But plans prepared by most yards expect too much construction experience from a novice. You'll want to augment them by checking how-to magazines and books for advice on specific techniques. That will give you confidence to shrug off discrepancies that creep into even the best construction blueprints.



Wall framing goes up in quickly assembled sections; raise long sides in halves. Keep lumber dry under a polyethylene tarp.

Add second top plate after framing walls, tying all together. Nail brace across squared doorway. Locate windows as you wish.

Gable siding goes on in three pieces, studs set forward 5/8" to lap siding below. Center cutout is for aluminum vent supplied.



Interior finish is extra. For year-round storage, we hit on ideal combo: 1/4" Peg-Board over Johns-Manville foil-face insulation.

Example: I ran into problems getting my garage package delivered, so I dealt with several yards in the same chain (Grossman's—serving the northeast, with a main office at Braintree, Mass. 02184) and I asked for plans from each. Surprisingly, though all the plans were for the identical garage, they differed in several construction details; it was a matter of choosing the soundest method.

I found the delivered load contained everything contracted for—with no skimping; I even ended up with extra lumber, and lots of nails. If anything, these "kit" garages tend to be over-designed. I followed the blueprint's insistence on the let-in diagonal bracing shown in our photos, but plywood siding makes such corner bracing unnecessary.

[Continued on page 130]

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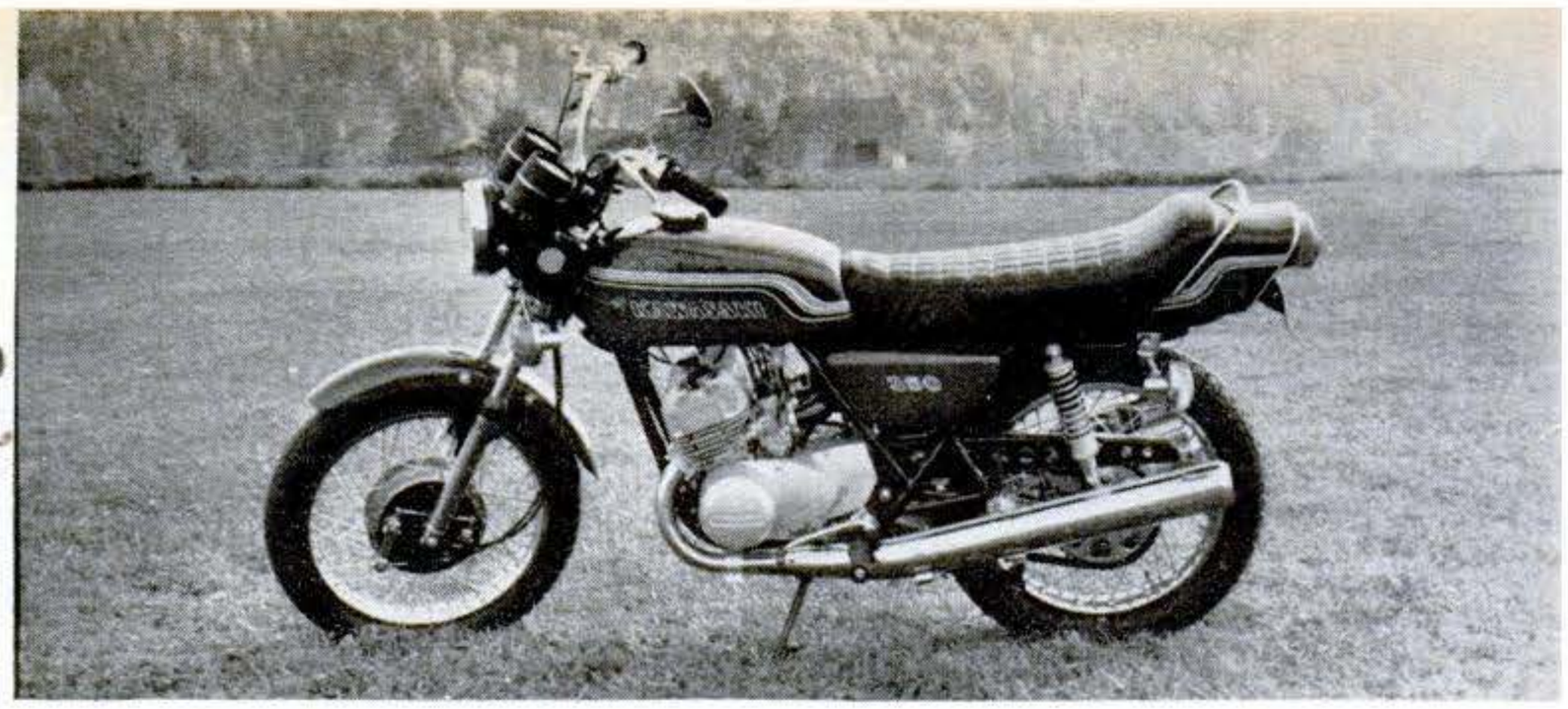
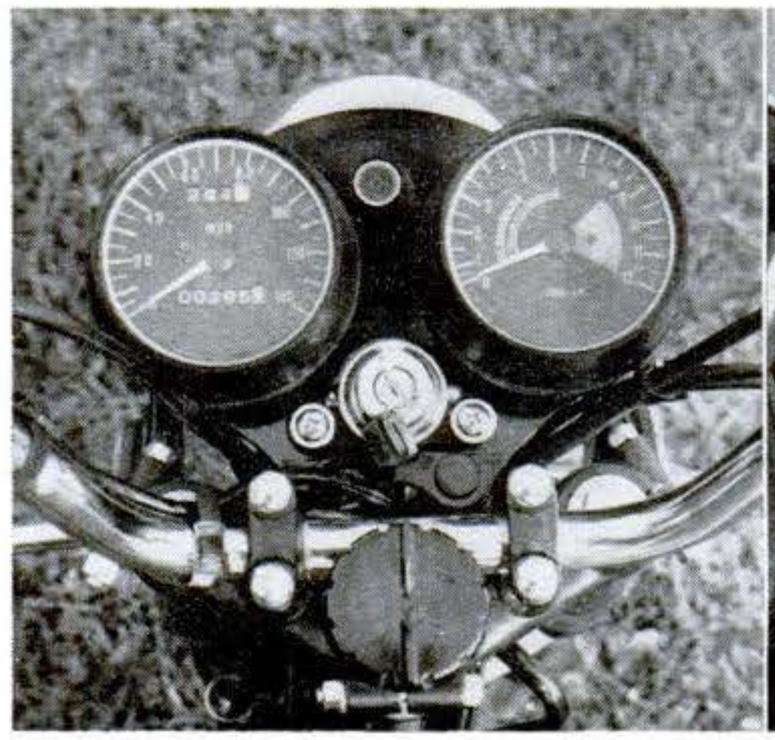
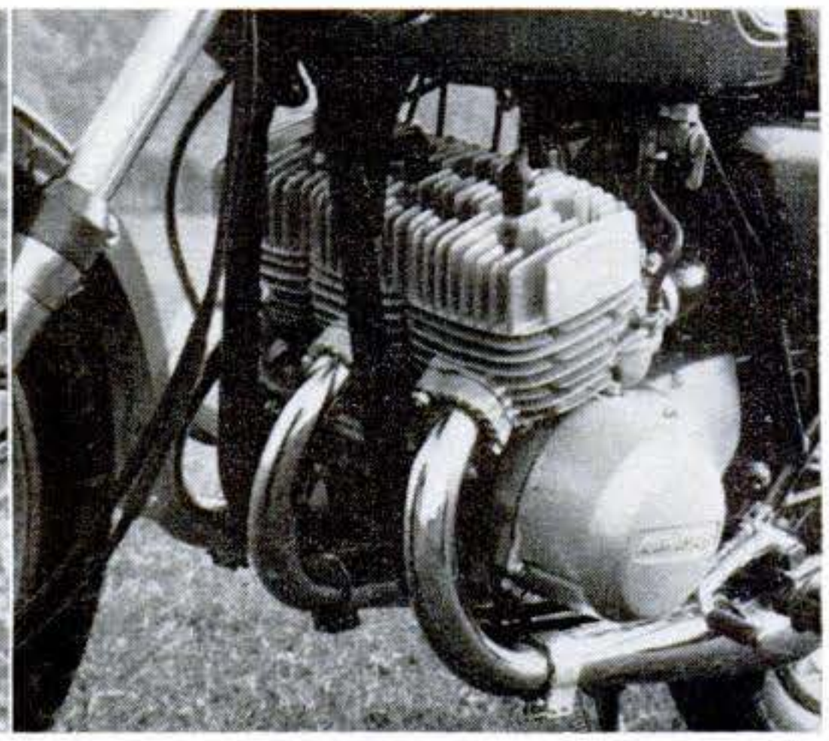
Acceleration of a demon, handling characteristics smooth as the movement of a fine watch—that's the Mach II motorcycle.



Fade-free brakes, turn signals, a loud horn, three-position adjustable rear shocks, and a comfortable saddle—all these make this 350 a great pleasure to ride.



The instruments are easy to read. Speedometer (left) has a resettable odometer. Tachometer (right) redlines at 8,500 rpm.



Three-cylinder vibration-free engine is oil-injected, requires no mixing of oil and gas. Oil tank holds 1.7 quarts.

KAWASAKI'S MACH II

Three-Cylinder Powerhouse

MACH II SPECS

Horsepower	45 at 8,000 rpm
Maximum torque	30.6 ft.-lb. at 7,000 rpm
Fuel consumption	76 mpg at 30 mph
Minimum turning radius	83 in.
Braking distance	39 ft. at 31 mph
Overall length	79.1 in.
Overall width	31.5 in.
Overall height	43.1 in.
Wheelbase	52.4 in.
Ground clearance	6.3 in.
Dry weight	329 lbs.
Engine type	2 cycle, 3 cylinder
Displacement	346.2cc
Bore x stroke	2.09 x 2.06 in.
Compression ratio	7.3:1
Ignition system	battery
Starter	kick
Carburetors	three 24mm Mikunis
Transmission	five speed, constant mesh
Clutch	wet, multiplate
Gear ratios, 1st	2.86
2nd	1.79
3rd	1.35
4th	1.12
5th	0.96
Transmission oil	SAE 20-30
Frame	tubular, double cradle
Suspension, front	telescopic fork
rear	swing arm
Brakes, front & rear	internal expansion
Tire size, front	3.00-18
rear	3.50-18
Fuel-tank capacity	3.7 gallons
Oil-tank capacity	1.7 quarts
Cost	$899

By RAY HILL

Searching for the perfect motorcycle? Don't give up and settle for less until you've tried the new Kawasaki Mach II—the first three-cylinder 350cc motorcycle in the world. I just put 850 miles on one.

Hot or cold, the engine always started on the first kick or two. Gear shifting's a breeze. Unlike many new machines, the Mach II lets you find neutral easily, anytime you want. I never missed a shift running through the five-speed gearbox.

In the first three gears the 45-hp engine can run the tach needle to the 8,500-rpm redline so fast, you've barely shifted gears before you have to shift again. From a dead stop, I ripped through the quarter mile to 87 mph. Top-end speed for the bike I tested was 94 mph. If you're an inexperienced rider, don't twist the throttle too hard until you get used to this little machine's rapid acceleration.

How does the Mach II handle? Like a dream. On an asphalt track I leaned it so low in corners that the foot pedal was scraping. The bike was steady as a rock.

The price is okay, too—$899.

Only one small beef: On a 300-mile trip at speeds between 70 and 75 mph, gas consumption was about 23 mpg. But then, nobody's perfect. PS

TO REMOVE SECTION for loose-leaf binding, open magazine wide at this page, rest it on table, run your thumb firmly along center fold. Then pull out the sheets gently, one at a time.

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PS EXTRA! 6-PAGE SPECIAL REPORT

Secrets of Keeping Your Automatic Dishwasher Trouble-Free

First rule: Use it right. Here's how—plus a lot of proven tips for making your own repairs

By EVAN POWELL

Chances are about 50-50 that the automatic dishwasher you probably have in your home is not giving the service it could. It may be washing the dirty dishes, but not the way it should (or could). A representative of a top maker of dishwashers tells me their records disclose that 45 to 50 percent of all service calls involve factors not related to equipment defects or failures.

The faults are related to the environment in which the dishwasher operates. The water may not be hot enough. There may not be enough of it. The detergent may have been on the shelf too long.

Testing the environmental factors ought to precede any repair. In fact, you may want to test your dishwasher even though it seems to be operating satisfactorily. First, however, you should understand the basic principles of automatic dishwashing.

A dishwasher works by making use of water pressure, heat, and chemical actions. An impeller or highspeed pump and spray arm produce the water pressure. The force of the water scrubs the dishes with hot water and detergent solution, loosening soil and flushing it away. A heating element, normally energized throughout the cycle, maintains the temperature. Detergent is added automatically during each wash period.

Dishes usually are dried by the heating element that maintains water temperature. With the final rinse water pumped out, the element raises the temperature within the machine and the heated air absorbs moisture. Since the dishwater is vented to room air, air flow occurs within the machine. Some machines have a small blower to increase air flow and speed drying action.

Checking your machine. With the operating principles in mind, you can make sure you're getting all the performance your dishwasher will deliver. In the process you can eliminate causes of many service calls.

First, check the water temperature. Let the machine fill with water on a normal cycle. Then advance the timer by slowly turning its dial clockwise. This will pump out the machine and let it refill. With the second water fill in the tub, stop the machine, open the door, and insert a candy or meat thermometer in the water. Temperature need not exceed 160 degrees, but a temperature below 140 won't dissolve grease or detergent.

Wipe your fingers across the lower front corners of your machine if it's a front-loader. A greasy black film indicates that water temperature is too low. If your water heater is set to a higher temperature than that being delivered to the dishwasher, remember that a loss of one degree per foot of pipe is normal.

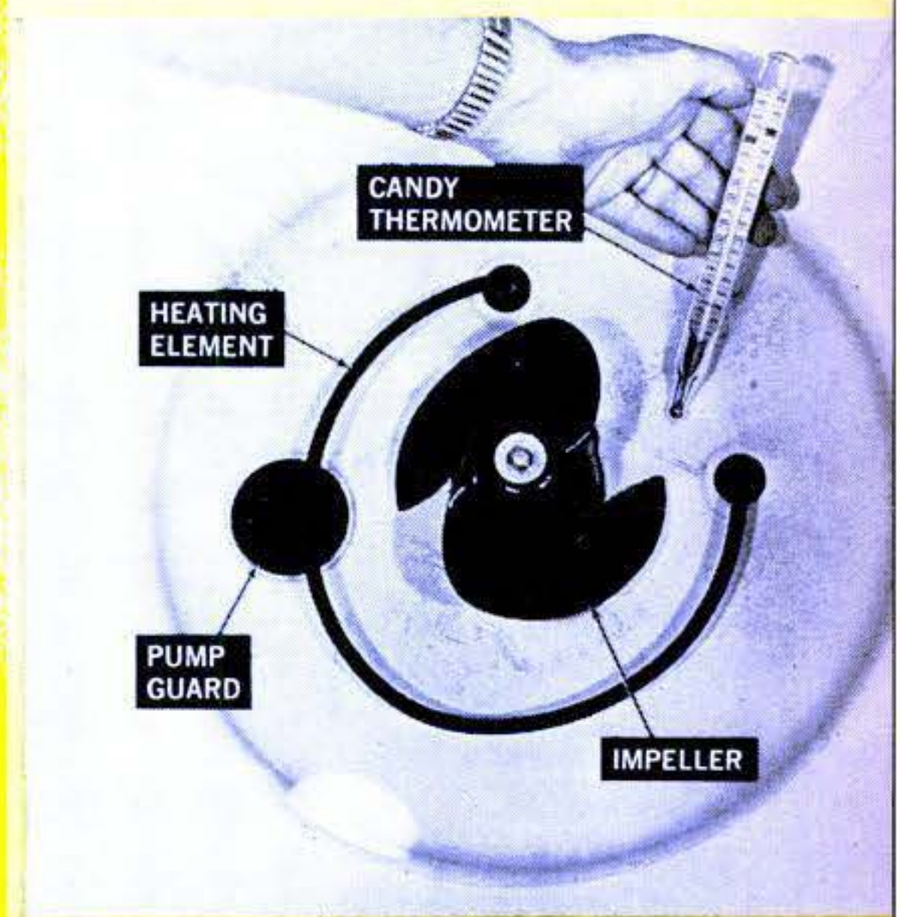
For the second test, observe the amount of water fill. The exact amount varies among different models of the same brand, but a good rule of thumb is that the water should reach the heating element. If it's low, be sure that you have adequate volume at the inlet line, or at the faucet if you have a portable model.

Filling a gallon container from the dishwasher supply shouldn't take longer than 30 seconds. Don't overlook the strainer in the faucet aerator or the one in the dishwasher's inlet valve. These may be restricted by foreign particles or algae.

Dishwashers use the "timed-fill" method for getting water into the ma-

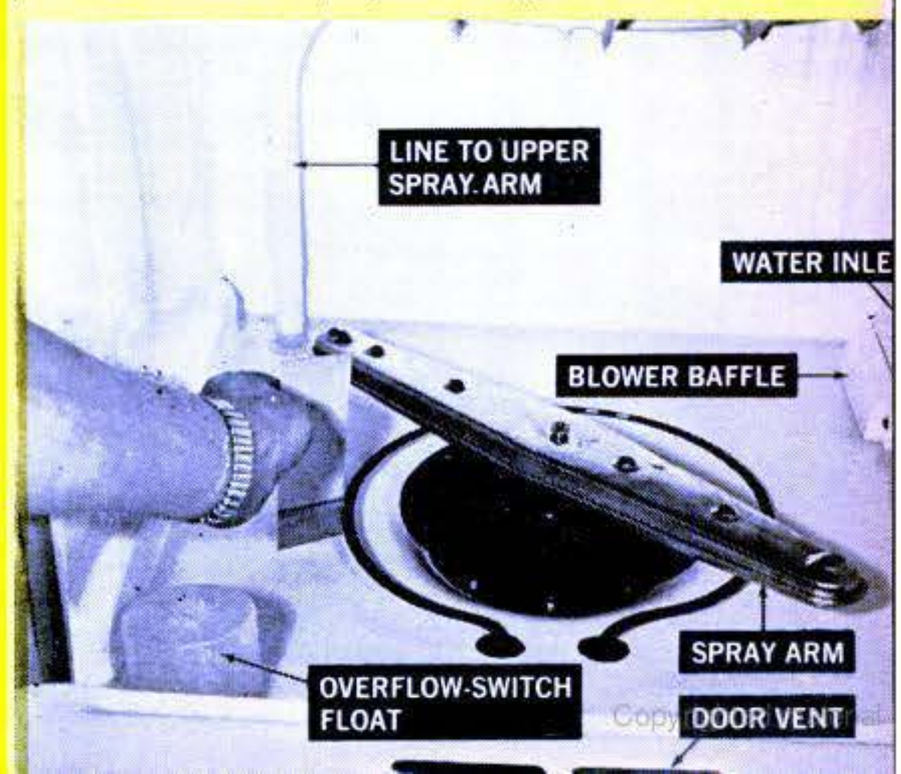
Continued

Load it right so dishwasher can do best job. Don't nest one dish in or against another, or block the water flow with a large dish.

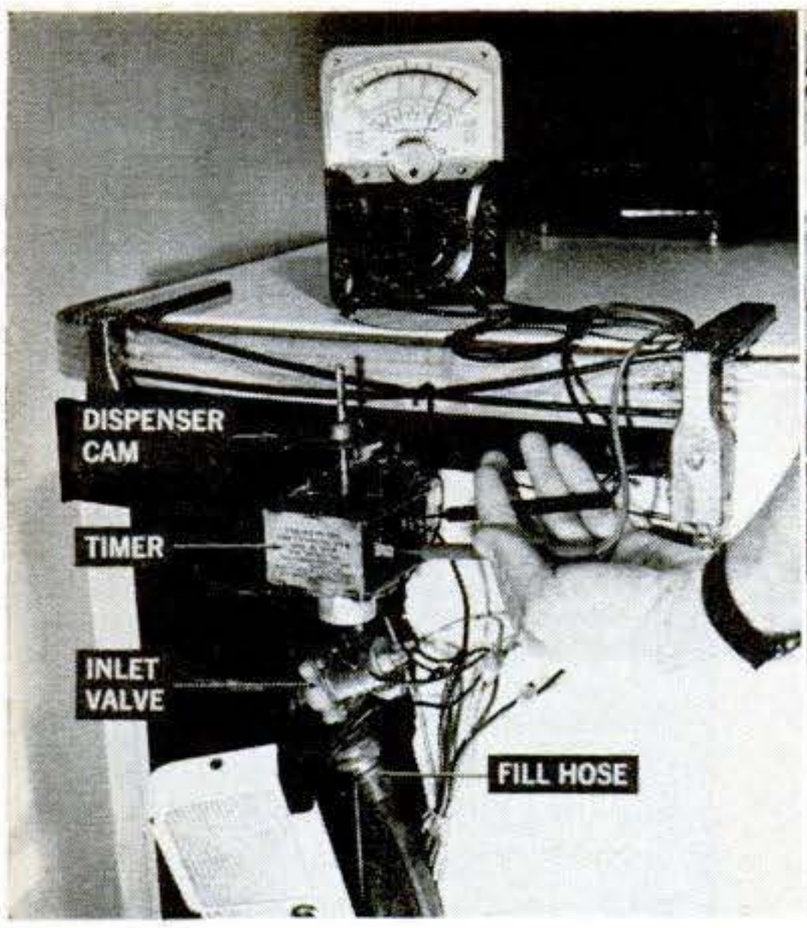


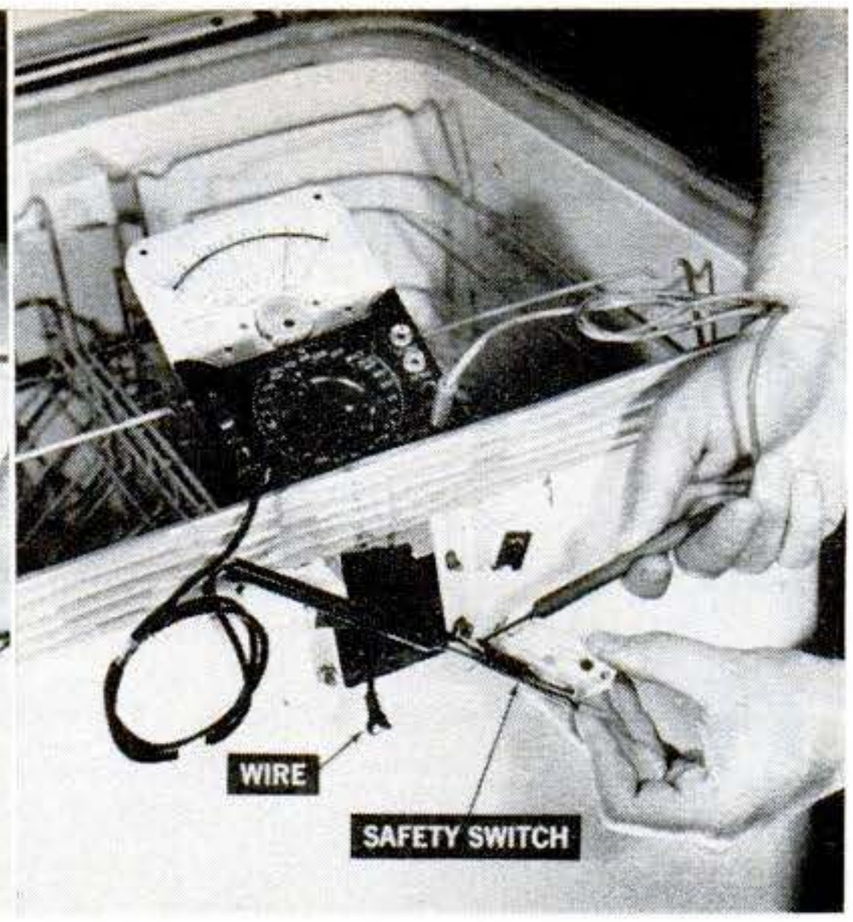
First checkpoint when a machine seems below par is water temperature. The magic number is 140 degrees. At lower temperatures washing action is greatly reduced. An ideal water temperature is 150 degrees.

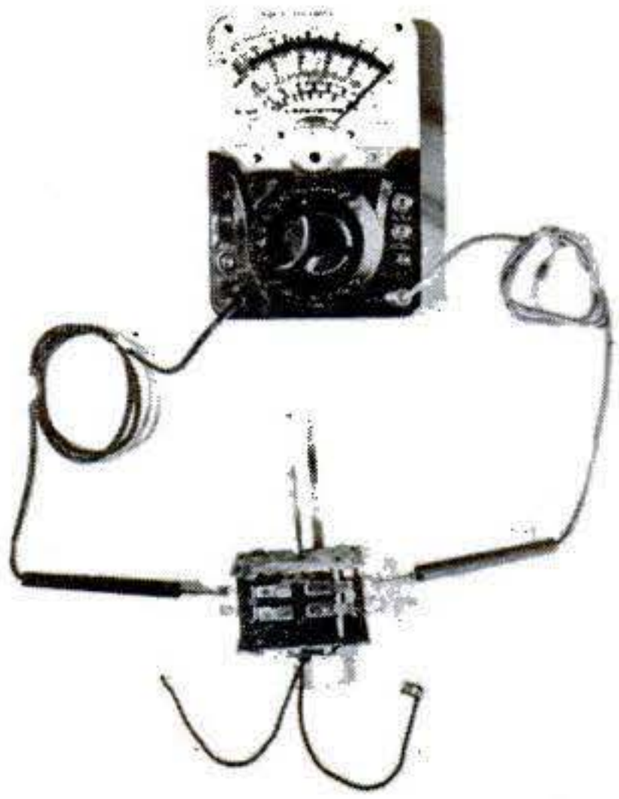
Second check is water level. Does water reach the heater? If not, suspect low pressure or restriction in line. Photo above shows older washer (type A) with an impeller. Below is spray arm (type B).



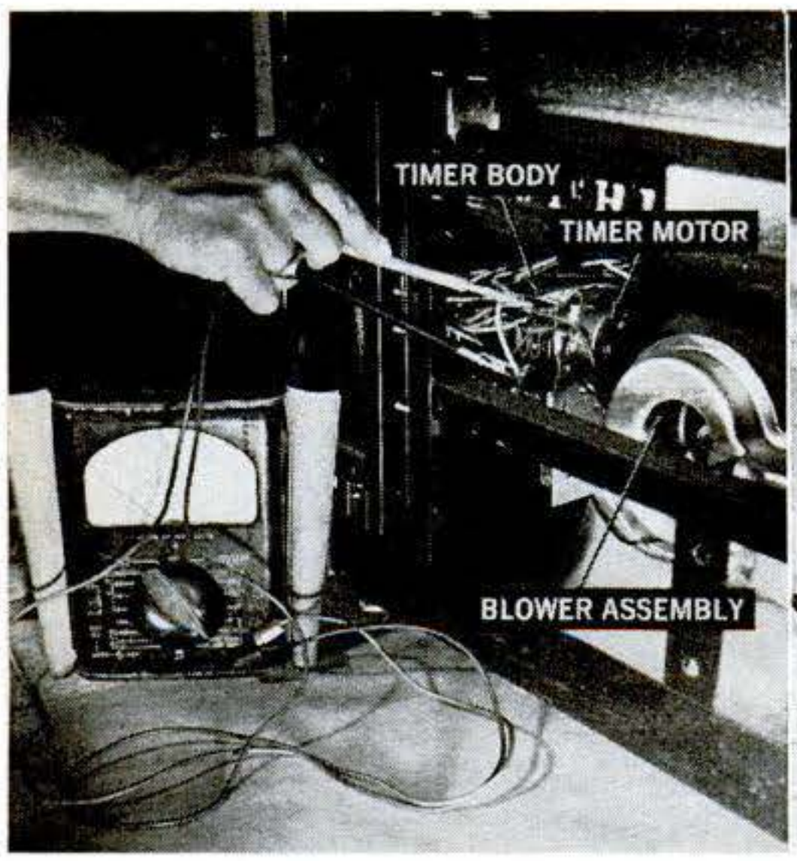
Volt-ohmmeter checks can spot the serious problems

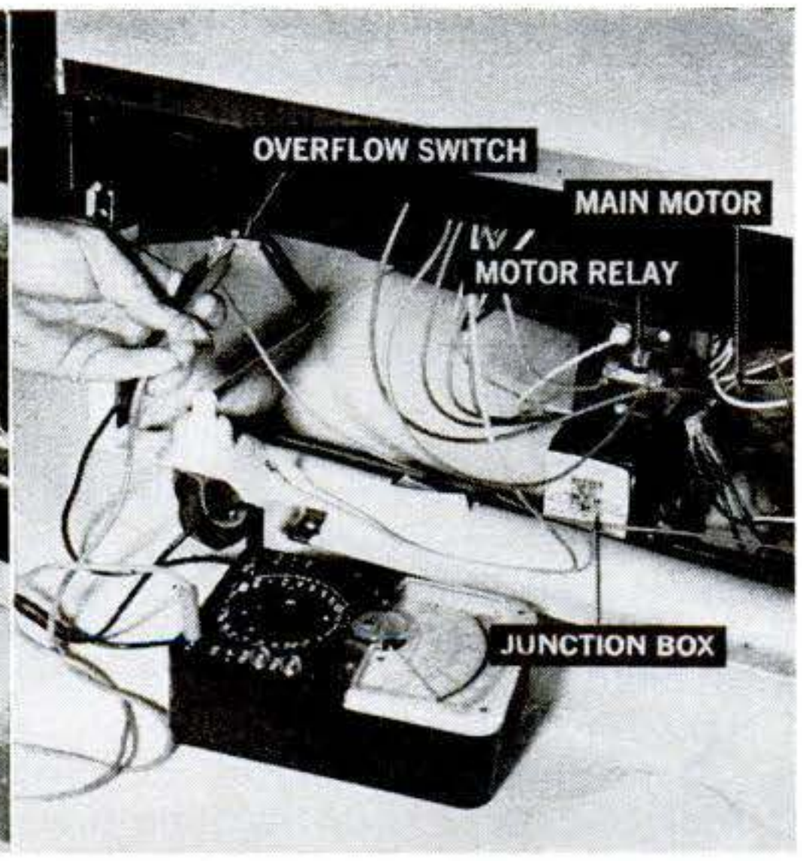






Defective components were spotted by the tests above. At left, resistance reading between contacts in timer indicated a fault. High resistance in switch contacts drops voltage to component, soon permanently damages contact itself. At center, corroded terminals in interlock switch caused high resistance reading shown. Unlike the "load," a switch should always show zero resistance. Switch contacts must be closed when tested. Switch plunger is being depressed with one hand in center photo while other hand holds probe. Cleaning contacts restored continuity to simple timer seen at right. Cover plate was removed to expose contact arms within timer. Probes are in position to permit a reading to be made through the suspect contacts.





Volt-ohmmeter is essential piece of equipment for tracing malfunctions in any home appliance operated by electricity. At the left above, one is being used to check for presence of voltage at the terminals to a timer motor, at the right for continuity through an overflow switch after the removal of a lead to the suspect component. For home appliance repairs, better get and learn to use one of these. For background information on this handy meter, and how to use it, see PS, Nov. '70, p. 110.

chine; any water-level switches are usually intended only to prevent overflow. Don't attempt to adjust these to control water level. A chamfered flow washer in the inlet valve regulates water pressure to approximately 20 psi (pounds per square inch), acting quite effectively in the 20 to 100 psi input range.

Finally, check your detergent. Dishwasher detergent is a highly alkaline compound formulated to loosen all types of food soil, to keep sudsing at a minimum, and to act as a wetting agent. It is quite unstable compared to other household detergents and has a short shelf life—about two weeks after the foil wrapper is broken. Watch for torn or cut outer wrappers when buying detergent. Close the pouring spout after using.

If detergent becomes caked it probably has passed its useful life. To test it, try the "two-by-two" test—place two teaspoons in a glass of hot water (not under 140 degrees) and stir for two minutes. If a gritty residue remains, the detergent is not satisfactory.

If you're not satisfied with the washing results, try another brand. Some brands work better in particular water conditions than others. Never substitute detergent made for dishpan use. A washing-by-hand detergent is much too sudsy for your dishwasher (and dishwasher detergent much too strong in the dishpan).

Your machine may also use a rinse conditioner such as Jet-Dry or Dish-Dri. One of these can be a big help in obtaining good washing results, especially in hard-water areas. Pri-

Continued

Keep those air gaps in your dishwasher plumbing

Plumbing codes require an air gap in the fill system of all dishwashers (see drawing on facing page). This is simply a gap, vented to room air, across which water must pass. It is usually located where water enters the machine. This eliminates the possibility of dishwasher water flowing back into the home water system.

Air gaps are not always required in drain lines, but they should be considered in undercounter installations. They're preferred if the dishwasher is connected to a disposer. An air gap or siphon break in the drain system prevents reverse flow from the sink waste line or disposer back into the dishwasher. A deck-mounted air gap—a Pre San #12 or equivalent—makes a neat installation with minimum loss of counter space. Since the sink faucet is high in relation to portable dishwashers, the hose coupling itself serves as an air gap.

Many dishwashers have a built-in drain loop to help prevent draining from the machine except when desired. Remember this, for if you must remove the loop when servicing, you must reinstall it properly. Locate it as high as the cabinet allows. Some undercounter models provide a separate drain loop; this should also be installed as high as possible, even behind the counter-top backsplash, if possible, and securely fastened.

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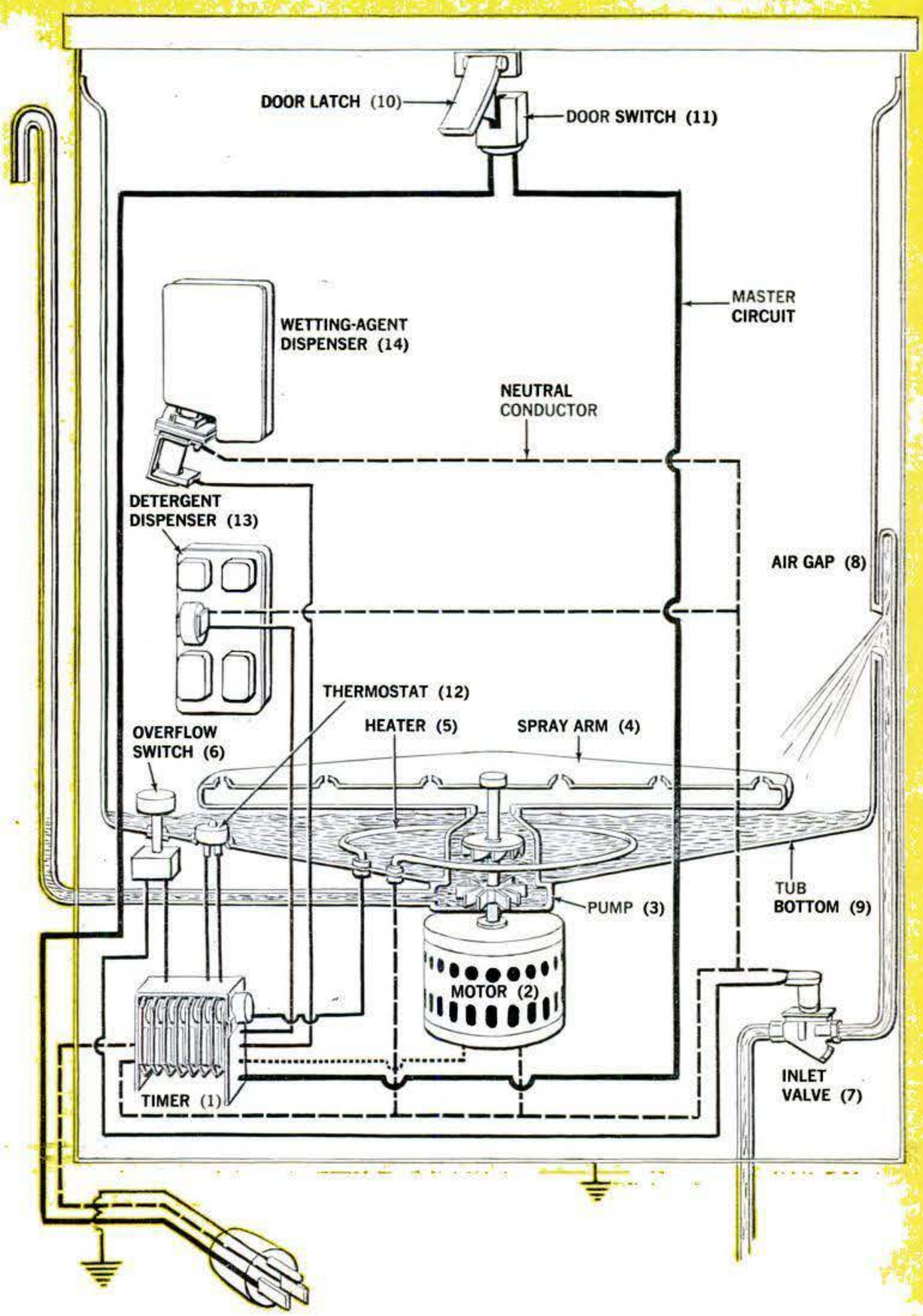
How a Typical Automatic Dishwasher Does Its Job



Mechanical operations: Phantom view of a typical modern dishwasher illustrates common locations of major components.

The timer (1) is often located behind a bottom access panel under the tub, although in an accompanying photo you'll note a timer placed behind an access panel above the front-opening door. The timer is advanced to the beginning of various cycles by a pushbutton-actuated motor.

The machine motor (2) drives a high-capacity pump (3) that forces water jets from a revolving spray arm (4). The motor may revolve in only one direction, with a solenoid-operated valve opening the drain line for the drain portion of the cycle; or it may revolve in one direction to wash, in the other to pump out water. Bidirectional motors have four entering leads.

A heater (5) maintains water temperature and usually provides heat drying. In addition, many models have a small squirrel-cage blower under the access panel to force air through the tub during the dry cycle. At least one uses a separate air heater incorporated in the air-inlet duct.

The overflow switch (6) provides a safety shut-off for the inlet valve (7). This switch may be float or diaphragm type. A built-in air gap (8) is always a required safeguard to prevent siphoning of tub water back into the fresh-water line in case of a pressure drop. Relative position of the tub-bottom within the cabinet is indicated at (9).

The door-latching lever (10) locks the door and activates the door safety switch (11), which controls all machine functions. A water-temperature-sensing thermostat (12) controls timer motor during sanitizing rinse cycle only, stopping timer until heater has raised water to 150 degrees in most machines. Detergent dispenser (13) releases detergent in each wash cycle, and wetting-agent dispenser (14) operates during final rinse. Components 11, 13, 14, and often 12 are located within the door on most front loaders.

Electrical operations: The electrical circuit shown by the broken-dash line is the neutral conductor, a grounded conductor which connects to each operating load in a 110-volt appliance and which serves to complete the circuit back to the power supply. This is not to be confused with the bonding conductor, a grounded lead that bonds each component and the frame of an appliance to ground through the middle (round) prong of a polarized line cord. The bonding conductor is a safety device and is not a part of the electrical circuit, while the neutral is. A neutral line should not be fused, nor should it be broken by a switch at any time.

The circuit drawn with a heavy line is the master circuit, providing the power supply from the AC plug, through the door safety switch (11) to the timer (1) from which it feeds all other operating circuits of the machine. The door must be shut and locked before the machine will function.

Circuit in dotted line is initiated from the timer (1) to operate machine motor (2). Reversible motors have four leads, usually with external relay. Direction of rotation of motor would be determined by the timer contacts.

Heater (5) is controlled by timer contacts, usually operating during wash, rinse, and drying. In models with a sanitizing-rinse feature, the auxiliary circuit, also shown, places the water-temperature-sensing thermostat (12) in series with the timer motor. When the timer reaches the final rinse cycle, the timer motor stops until heater has raised temperature to a predetermined level (around 150 degrees). Heat rise is usually one to two degrees per minute. Prolonged delay is an indication that the water supply to machine is too cool.

Timer energizes inlet valve (7) by way of the overflow switch (6), which must be closed to complete the circuit. Since water flow rate through inlet valve is constant because of action of flow washer, elapsed time of fill cycle determines the amount of water that enters machine. Overflow switch shuts off inlet valve in the event of overfill due to abnormally high water pressure (over 100 psi) or timer malfunction.

Dispenser (13) is actuated by timer during wash cycle. Most dishwashers empty one side of dispenser when door is shut at beginning of wash, uncover other side when unlatching solenoid is energized by timer during second wash period. Such dispensers are "one-shot" dispensers—they must be filled as a part of your routine for starting dishwasher.

Wetting-agent dispenser (14) is energized by timer during final rinse, injects only a few drops when energized. Storage reservoir holds three to six months' supply.

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The stages in a typical dishwashing cycle

A typical washing cycle includes the following stages (the figures show the approximate time the average machine devotes to each stage):

First wash. Removes loose, heavy soil deposits. 8 minutes.

Pumping. 1 minute.

Second wash. Fresh charge of water and detergent removes anything left from first wash. 10 minutes.

Pumping. 1 minute.

First rinse. Flushes detergent from dishes and tub. 2 minutes.

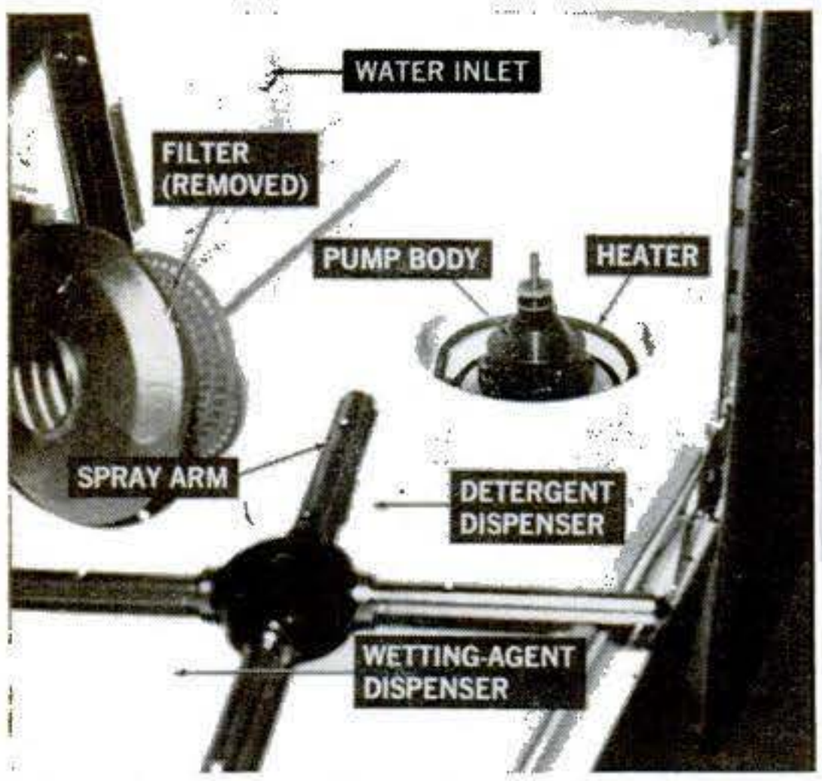
Pumping. 1 minute.

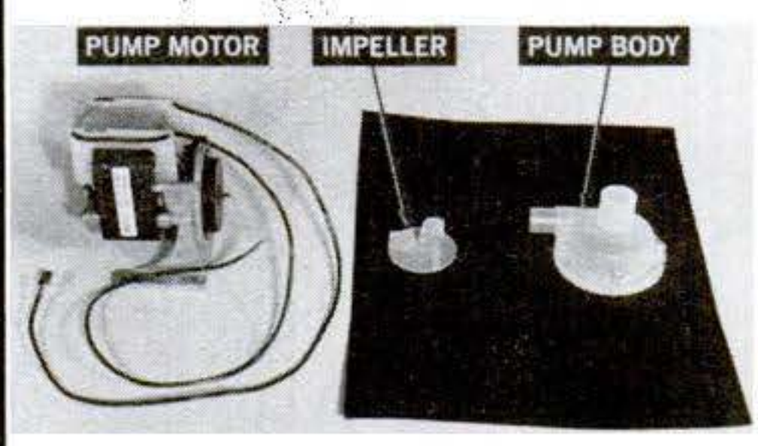
Second rinse. Flushes any remaining detergent, prepares dishes for drying. Sanitizing cycle takes over during this rinse if machine is so equipped and/or selected, raising the water temperature to destroy bacteria. Wetting agent is introduced near the end of this rinsing period to reduce spotting as the dishes dry. 2 minutes.

Pumping. 1 minute.

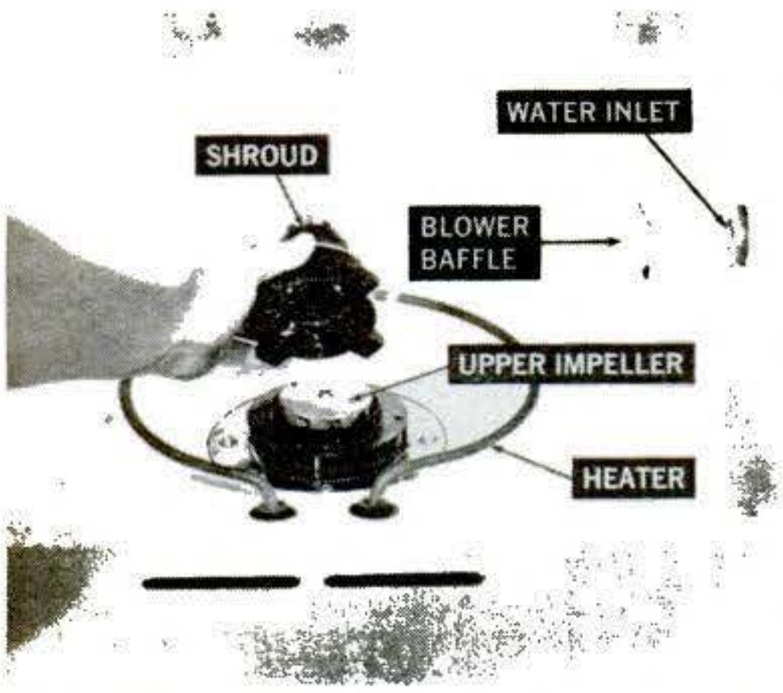
Drying. Heater(s) energized after all water is pumped from tub, raising the air temperature and, in some models, forcing air across the dishes with a blower. Air absorbs moisture and is vented into the room. 18 minutes.

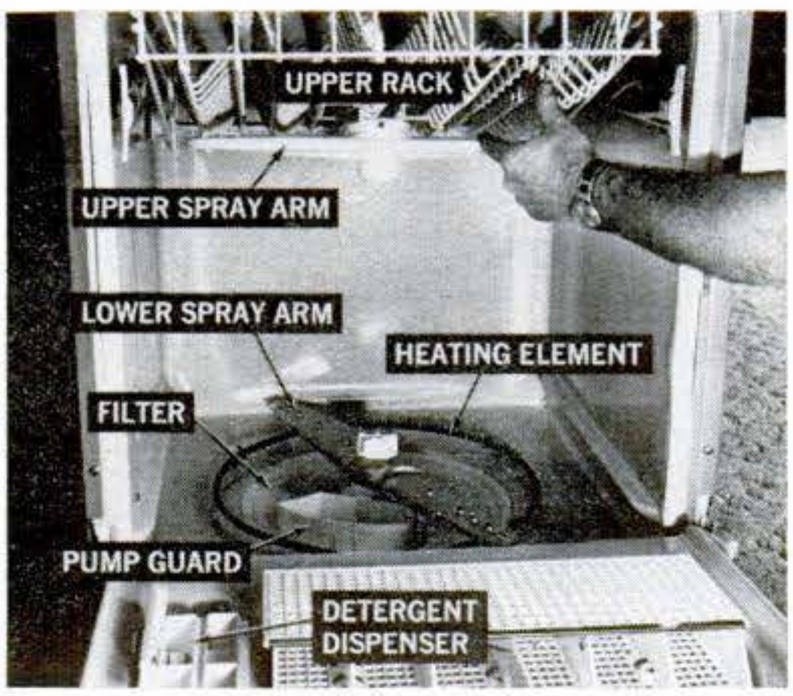
Get acquainted with the mechanical parts inside



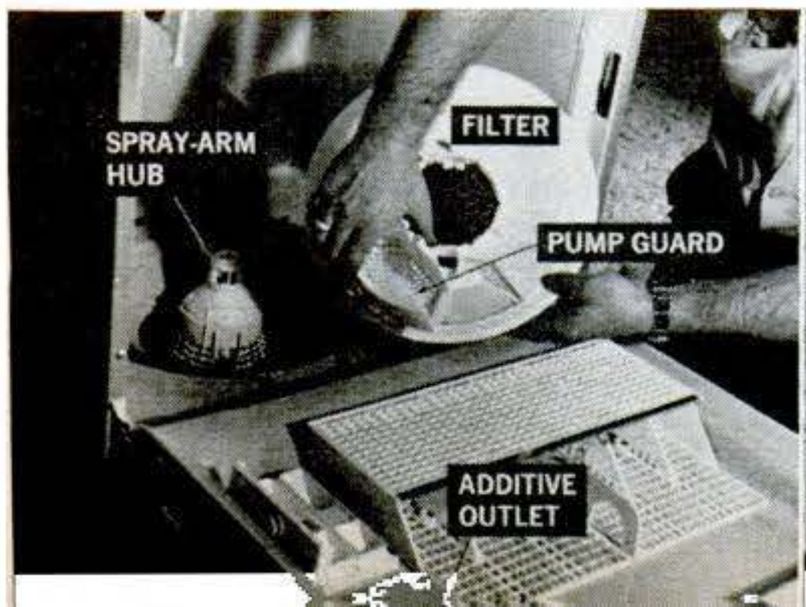


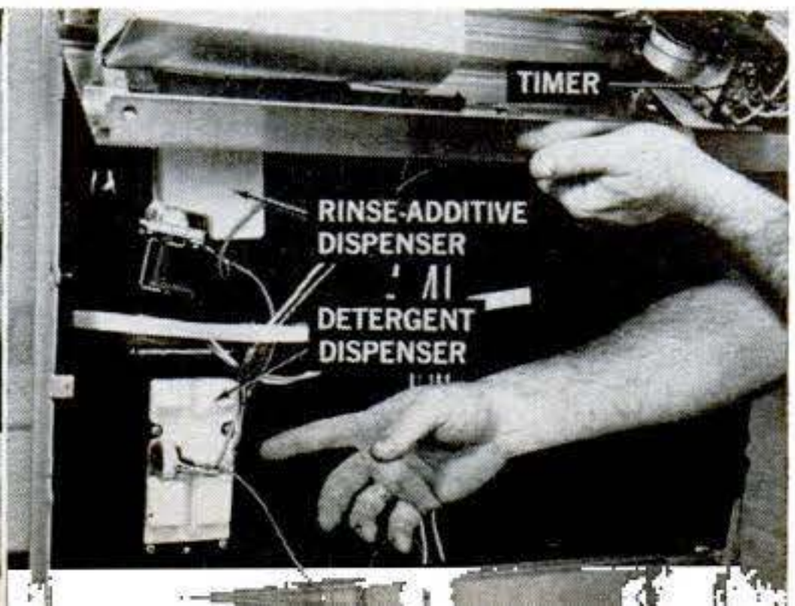
Pump is uncovered in the washer shown above by lifting the spray arm and removing the guard that protects the impeller. Both removed components can be seen in foreground. Pump assembly seen in photo at right, above, is typical of those found in older (type-A) dishwashers. Motor is mounted to pump housing and seal plate. Impeller threads onto motor shaft and pump cover bolts to the pump housing.





High-speed pump used on newer (Type-B) washers mounts directly on main motor shaft. In photo above, the diffuser is removed to uncover the pump's upper impeller. In photo at right, you see that Whirlpool washer has a spray arm for upper rack as well as one below. A jet of water from pump in bottom strikes center of upper arm, causing arm to rotate and jet water from holes in its upper surface.





Filters and strainers in most dishwashers have a double function. They guard the pump, and they help prevent food particles from resettling on washed dishes. At far left, a Whirlpool filter is easily inspected. It is largely self-cleaning.

The door of a dishwasher holds many operating components. The outer panel is easily removed for access. In Whirlpool at near left, timer and selector switch were found in the upper panel, rinse-additive and detergent units below.

marily wetting agents, they reduce water surface tension, allowing the water to flow off the dishes.

This reduces mineral staining and spotting. Most additive dispensers, injecting a few drops during the final rinse, hold about three months' supply. Check the level periodically. If your machine has no dispenser, additives are available in cake form for suspending from the basket. This works well.

When your machine meets all of the simple tests just outlined, you can be sure that you must look deeper for any trouble that develops.

Understanding the washer. Mechanical components usually are mounted directly to the motor shaft. In older units, which I will refer to as type-A washers, an open impeller spins in the sump of the tub, throwing water against the dishes with great force. In these units the main motor turns in one direction only, and the pump is often powered by a smaller motor. Some models eliminate the pump, and use a solenoid-operated dump valve to empty the water into the drain by gravity flow.

Troubleshooting motors. First, look at the bell housing on the motor and determine whether it has a manual-reset protector—on type-A machines, many do. Push the reset button and listen. No hum or noise at all? Check for voltage at the motor terminals with a volt-ohmmeter (VOM). A short, relatively loud hum (less than four seconds) followed by the overload protector kicking out indicates that both running and starting windings are being energized; check for foreign objects jamming the impeller, or stuck motor bearings.

If it hums or buzzes for a longer period, chances are that the run winding only is being energized; check the motor centrifugal switch. Problems in this area require removal and disassembly of the motor. It's best to let a motor-repair shop replace the switch; it must often be fabricated to fit the motor.

The impeller itself is critical on type-A machines. Chips and breaks on the leading edge cause erratic spray patterns and greatly reduce washing efficiency. Damage to impellers is caused by foreign objects, primarily silverware, dropping into the sump. If confronted with this problem, inspect the silverware bas-

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ket and be certain the machine is being loaded according to instructions.

The shaded-pole motor that powers the pump on type-A dishwashers is a rugged device. If water doesn't pump out, check to see that the pump is turning freely; you can often tell by turning the motor shaft with long-nose pliers. If it's binding, disassemble the pump and inspect for foreign objects.

A strainer, usually in the bottom of the tub, protects the pump. It's a compromise, however; its openings must be large enough to allow soft food deposits to pass and be flushed away, but small enough to stop bits of bone, glass, olive pits, etc. The problem lies in *small* pieces of hard material. Check the strainer carefully —it's a tough feeling when you reassemble the pump only to hear the "chunk" of another object lodging against the impeller.

If the pump turns freely, check the pump motor for continuity with your volt-ohmmeter. If okay, you may find that timer contacts aren't supplying voltage to the motor.

The new breed. You'll recognize a type-B machine by the absence of an open impeller at bottom of the tub. In its place will be a stainless-steel or plastic spray arm, perforated with water-jet nozzles.

Water is directed from a high-speed, high-efficiency pump into the spray arm, making it revolve and direct its water jets to every inch of the tub. Some deluxe models use two arms or a spray tube and revolving rack to accomplish two-level washing. The motor turns in one direction to force water through the spray arms, and reverses to force it out the drain.

Checkout procedure for the motor is much like that for type-A washers, except that there is only one motor and there may be a current-operated relay rather than a centrifugal starting switch. It also may be reversible, and if this is the case, there will be four motor leads.

One lead is common to both windings, one energizes the running winding, and the other two energize the starting winding. Only *one* starting lead is energized at a given time, for this determines the direction of motor rotation. Check the color-coding of these leads before disconnecting for testing, and be sure they are reconnected in the same manner.

Repairing the high-speed pump. The pump assembly is mounted directly to the motor shaft. It often consists of two impellers—the upper one, the wash impeller; the lower one, the drain impeller. In many machines the lower impeller also circulates water to the upper spray arm or spray tube

Continued

Your Quick-Check Chart for Automatic Dishwashers

Symptom	Cause	Remedy
Water will not enter machine	Filter screen clogged	Remove and clean with toothbrush Remove screen on faucet aerator (portable)
	Inlet-valve solenoid open	Test with VOM—replace if open
	Interlock switch on door not making contact	Test with VOM—adjust or replace
	Overflow switch jammed or open	Adjust or replace
Water will not shut off	Foreign particles in inlet valve	Remove and clean
	Inlet-valve solenoid grounded	Test with VOM—replace if grounded
	Timer contacts stuck	Repair or replace timer as necessary
Motor will not run	Impeller or pump jammed	Inspect and clear, check for damage
	Manual overload kicked out	Check for cause and reset
	Centrifugal switch or relay out	Repair or replace as necessary
	Shorted or open motor windings	Replace motor
Water will not pump out	Type-B machines, see inoperative motor (above)	Repair inoperative motor as indicated
	Strainer clogged (Type A)	Remove and clean
	Line or passageway restricted	Inspect and clear
	Impeller sheared or loose	Repair or replace as necessary
	Impeller jammed	Remove foreign object
	Pump motor inoperative	Test with VOM—repair or replace
	No voltage to pump motor	Test timer and connecting wiring
Timer will not advance	Open windings in timer motor	Test with VOM—replace if open
	"Sanitize" thermostat open	Check stat with VOM, check water temp.
	Timer binding	Inspect and lubricate with care
Food particles left on glassware	Water too cool	Supply should be minimum of 140°
	Insufficient water charge	Should reach element
	Spray arm(s) not revolving	Inspect for binding and repair—may be caused by utensil protruding through rack
	Insufficient detergent	Fill cups full
Dishes not drying properly	Water too cool	Supply should be minimum of 140°
	Heating element open	Check with VOM—replace if open
	Blower motor inoperative (if so equipped)	Inspect for binding, test with VOM
	Wetting-agent dispenser empty	Refill—if not equipped, purchase solid type wetting agent available at markets
	Condensation	At end of cycle, open door a crack for 5 minutes before removing dishes
Leaking	Improper door adjustment	Inspect and adjust as necessary
	Hoses crimped or loose	Check and repair
	Sudsing	Check detergent and water temperature
	Split spray arm	Inspect and replace if necessary
	Gasket torn or hardened	Inspect and replace if necessary
	Leak in tub	Repair with epoxy
	Machine not level	Check and level as necessary
	Air gap splashes or overflows	Check for loose hoses or misalignment
Excessive noise	Foreign object in pump or impeller	Inspect and remove object
	Improper loading	Check for utensils striking arm or tub
	Loose sheet metal	Locate and tighten loose panel

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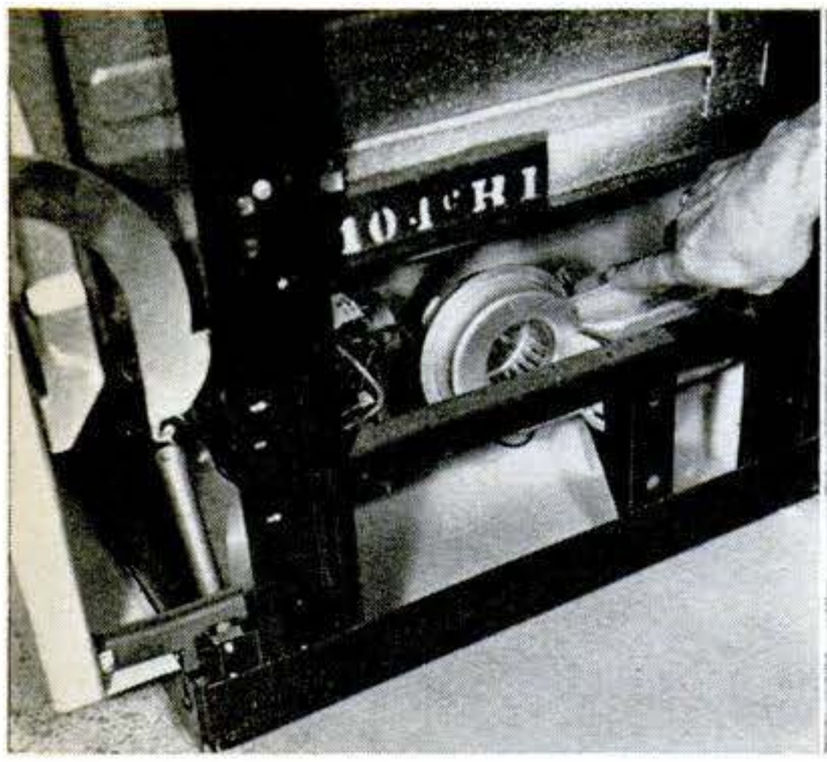
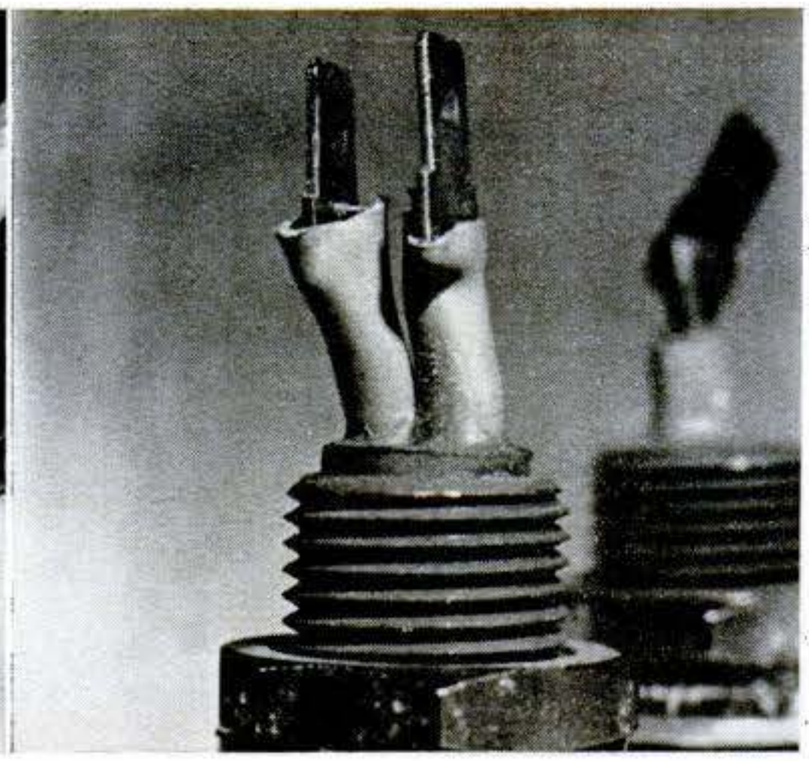
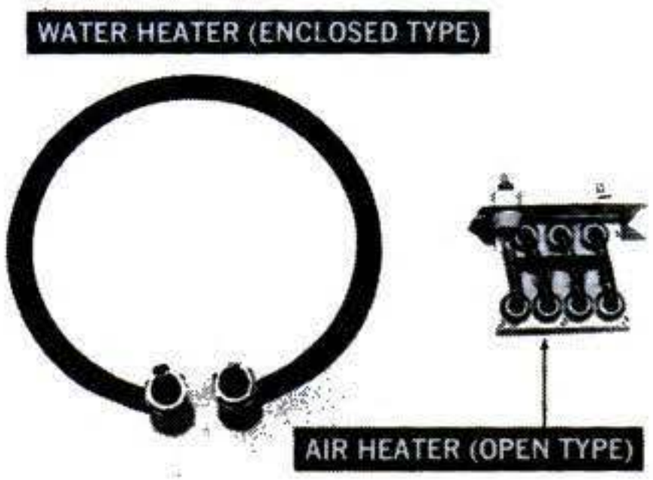
Two types of heaters circulate air to dry the clean dishes







Washed dishes are dried by a duct-mounted heater and blower on the KitchenAid shown above. Position of heater in duct is indicated. Some KitchenAid models use a dual-element water heater with two terminals (center photo). The calrod heater shown in photo at right is similar to that used on most machines. The heater is energized throughout cycle in most cases, serving to maintain water temperature and dry the dishes. Note the differences in this photo between calrod and open-type heaters.

when the motor is turning in the "wash" direction.

Keep these tips in mind when servicing the type-B pump. The impeller is often made of aluminum. Electrolytic action may have frozen it to the steel motor shaft. If so, apply a few drops of penetrating oil to the top of the impeller; then drill a series of ¼" holes around the base of the impeller to (but not into) the motor shaft. A few light taps of a hammer should now loosen the tightest grip. Go easy with the hammer—don't risk bending the motor shaft.

Look closely for small brass washers used to shim impellers for proper clearance and retain these for use with a new impeller. Many firms furnish shims and an alignment gauge with each replacement impeller.

If an impeller is sheared, count the blades on the replacement and be sure that all pieces of the old one are recovered from the lines and pump housing. Any piece remaining may return to the pump and damage the new assembly. It's also a good practice to replace the pump seal when changing an impeller. Normally a spring loaded, carbon-faced seal, it's cheap insurance against leaks near the motor.

Finally, don't attempt to override the door safety switch to "see" if the pump is operating; you wouldn't believe that you could be so wet so fast. Clear-plastic doors and lids are used to study spray patterns in dishwashers; the water action is incredible.

Locating leaks. The secret here is to get where the action is. Remove panels to expose every possible portion of the equipment and pinpoint the source while it's happening. Look closely around the area of the siphon break where the water enters the tub, and around the inlet valve, pump housing, and seal area.

Inspect hoses and clamps. Check the door carefully—most front-loaders incorporate a dam in the door which may spill over if improper heavy-sudsing detergents are used or if a spray arm develops a split or leak. Check all gaskets. If hardened or torn, replace them.

Water doesn't shut off? Suspect the inlet valve (if it continues to flow into the machine when the power is shut off or the plug is pulled, your suspicions are confirmed). The single-port valve (for hot water only) probably has foreign particles in the bleed ports of the diaphragm. Disassembling and cleaning, with particular attention to the filter screen, should eliminate the problem.

Timers and "sanitizing" rinse. The dishwasher timer is similar to that on an automatic clothes washer (except for the sanitizing feature on some models). At a predetermined point, usually in the final rinse, contacts within the timer open and interrupt power flow to the timer motor. A thermostat outside the tub or in the door senses the water temperature.

When temperature is approximately 150 degrees, the thermostat contacts close and again supply power to the timer motor. Often a light is incorporated in the circuit to signal when the timer is not advancing because water is being heated.

Don't assume that the sanitizing feature compensates for low-water temperature. This heating occurs *after* the wash water and detergent solution have done their job. A long delay period can in fact indicate that the water supply is too cool for good dishwashing. Most dishwater heaters raise water temperature only one or two degrees per minute, depending on heater size and voltage. A 30-minute delay could indicate that water entered the machine at only 120 degrees, much too cool for proper washing. On the other hand, a slight delay or no delay at all means that the water temperature is well above minimum requirements.

There is some misconception regarding the term "sanitized." According to public health standards, it means that less than 100 colonies of bacteria per dish can be recovered. Dishes are not sterilized (*all* microorganisms destroyed), but it's the next best thing.

"Washability." This is a dishwasher term with many connotations. From time to time washing problems may arise with certain dishes or tableware, or with certain other external factors. They are almost always due to area problems—water hardness, mineral content, etc. (See chart.)

Helpful hints. Don't wash dishes during peak periods of hot-water use. Clothes-washing and shower demands can reduce temperature of incoming water. If you want to store used dishes in the machine and run the washer once a day, fine—but don't hold them longer than one day before washing. When loading large platters, keep them away from the detergent dispenser; they can obstruct water flow to the dispenser cups, and detergent must wash out easily as soon as the compartments open.

Use your VOM to be sure line voltage is within the 10 percent tolerance required for appliances. Test with washer in operation. A heating element rated at 1,000 watts at 125 volts delivers only 625 watts at 100 volts.

You may now have the impression that your automatic dishwasher is influenced by so many factors that you can't expect satisfactory performance. It isn't so. Just meet its few simple demands and it will be a faithful servant for many years. PS

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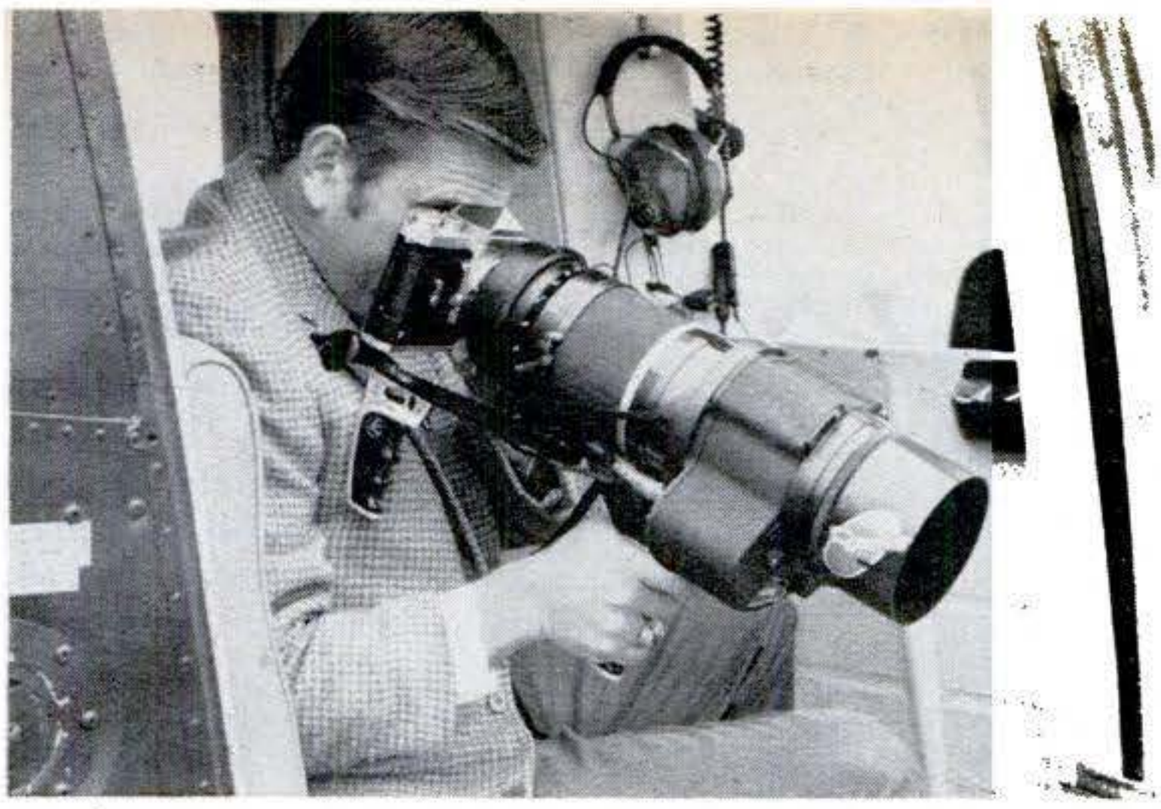


Dynalens system here couples a Nikon F with motor drive, a 1,000mm Nikkor lens, and the Dynalens image stabilizer. You can easily shoot sharp, hand-held photos with this rig.

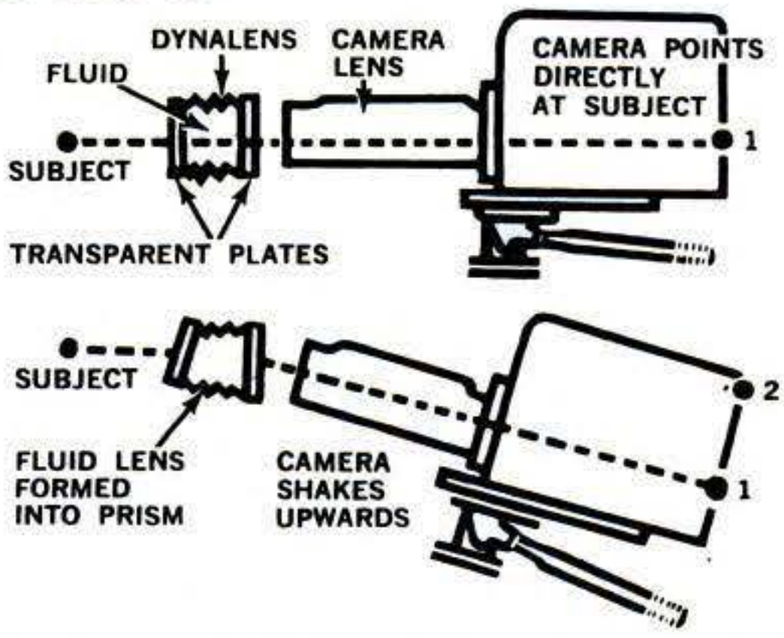
Liquid Lens Takes the Shakes Out of Pictures

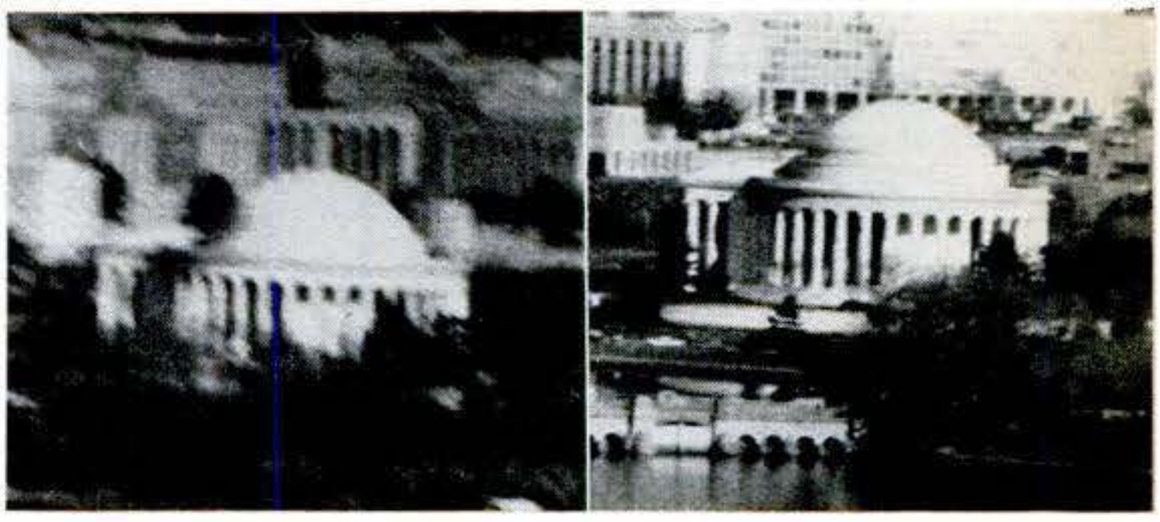
Jiggle your camera during an exposure and you get a fuzzy picture? This photographic axiom no longer holds true. There's an optical system that so effectively takes the shakes out of shaky pictures that you can use it to shoot sharp hand-held photos with long lenses at low shutter speeds. You can even shoot from the deck of a pitching ship, or out the door of a gyrating helicopter—you'll still get crisp, clear images.

The system—Dynalens, made by Dynasciences Corp., Bluebell, Pa.—is applicable to all types of photography: motion picture, still work, and TV. Yes, it's expensive —$8,500 for the system shown at left.—*Paul Wahl*

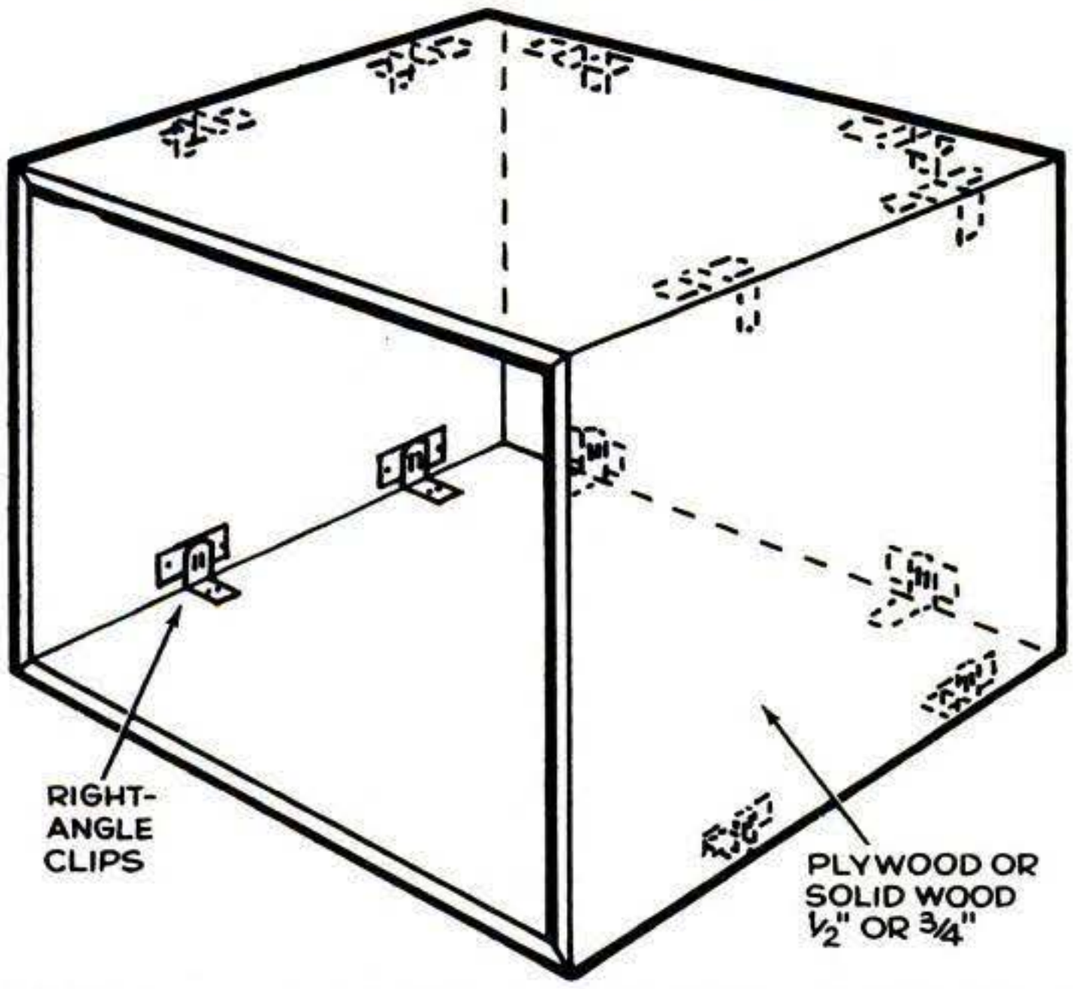
How it beats the shakes

Fluid enclosed in a bellows between two glass plates forms a liquid lens. Gyroscopic sensors detect and measure camera movement, send electrical signals that program liquid lens to prism angle required to keep image focused at 1 rather than shifting to 2.





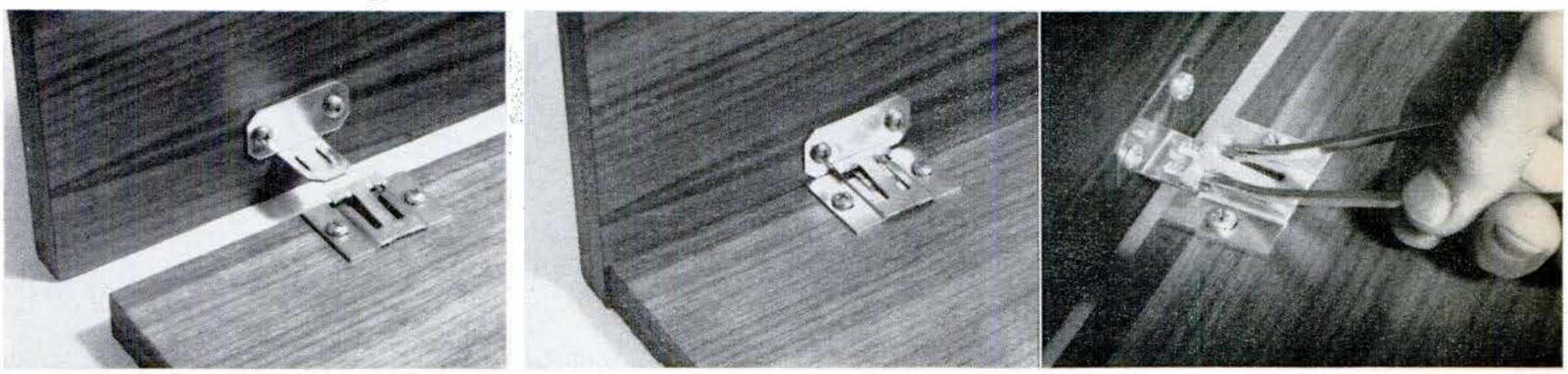
Compensated image, above right, is far sharper than uncompensated image, above left. Both were shot from a moving helicopter with a 35mm SLR at 1/60 second. Lens was a 400mm.



Assembly's a Snap with New Locking Clips

Ever build a cabinet and later have to take it apart to set it up elsewhere? Now you can build it and knock it down without having to fuss with nails. New K-D (knockdown) Snap Fast Clips come in two parts. Just screw them on and snap them together. They lock in tightly. The T-shaped plate on the female fitting is flexible for easy disassembly.

The clips come in many sizes and shapes—including flat instead of right angle, hinged for doors, and rounded for legs. Projects? How about the box table at left? With hinges on top, it'll double as a storage cabinet or toy box. The clips cost 39 cents to $1. From Ajax Hardware Corp., 825 S. Ajax Ave., City of Industry, Calif. 91747—*Doug Garr*



It's a cinch to assemble: Just snap together the male and female fittings. Ridges lock in under the T-shaped plate of the female fitting (center). Want to take it apart? Just use a screwdriver or other pry device to lift the T plate (right).

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FOUR QUICK AND EASY IDEAS

Set of 10 coasters stacks neatly inside a five-inch cube for storage.

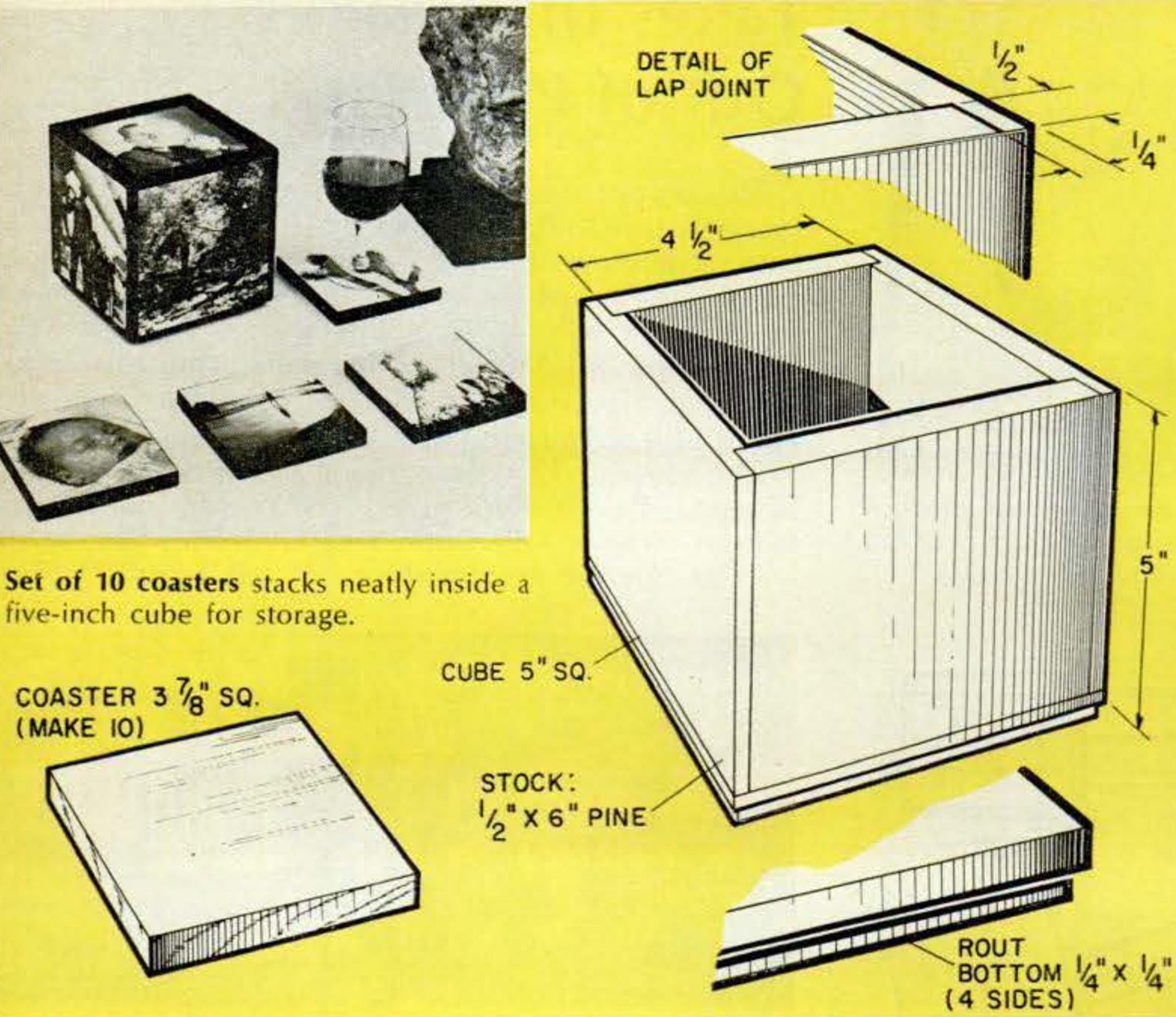


Photo Coasters

Make this set of man-sized coasters and you'll protect your furniture while you display your favorite photos. For storage, the entire set stacks neatly inside a five-inch cube that doubles as a contemporary accent piece.

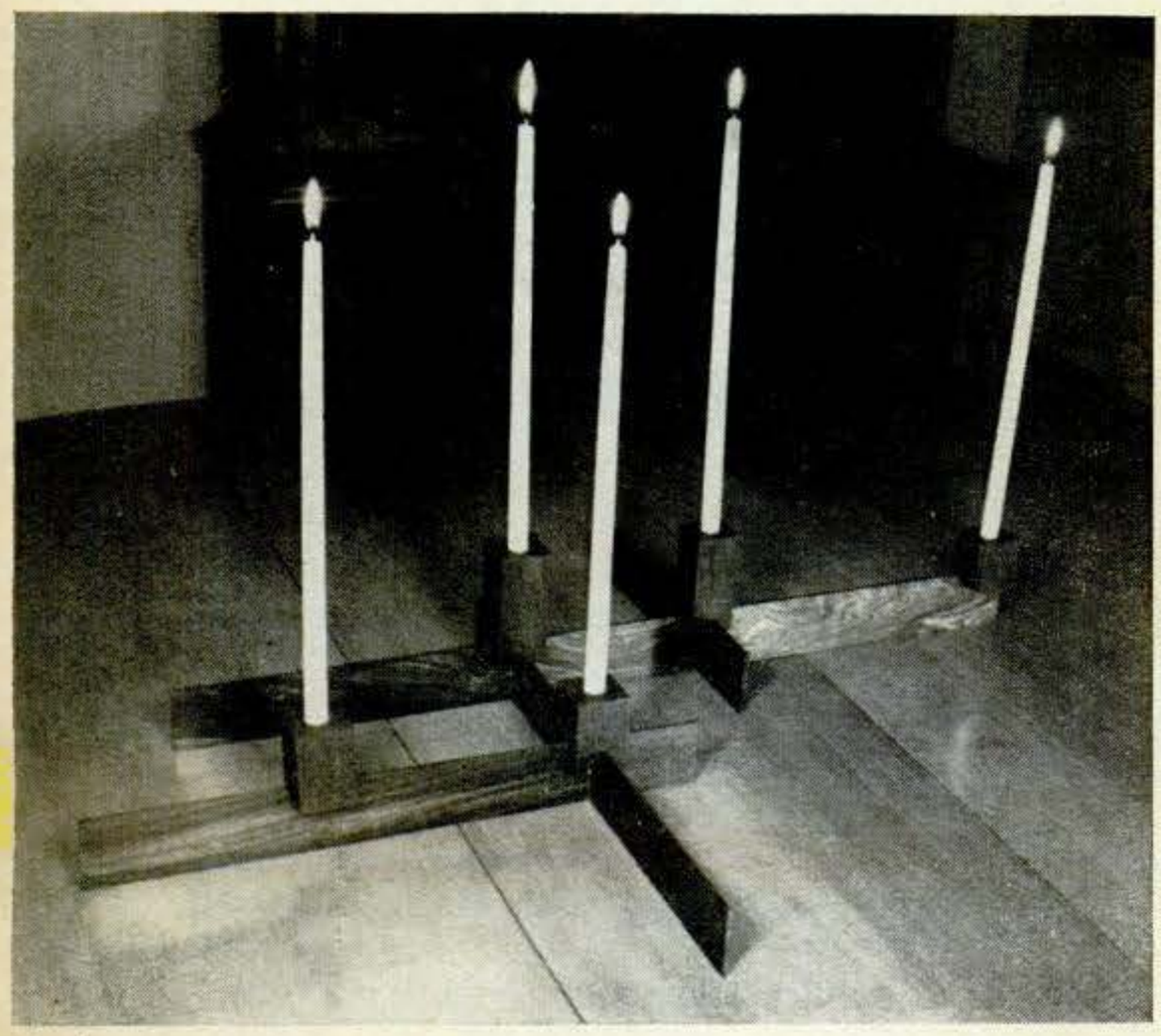
Both coasters and cube are made from clear half-inch pine. Use lap joints at cube corners, and assemble with glue. Rout the bottom of the cube 1/4" by 1/4" for a floating look.

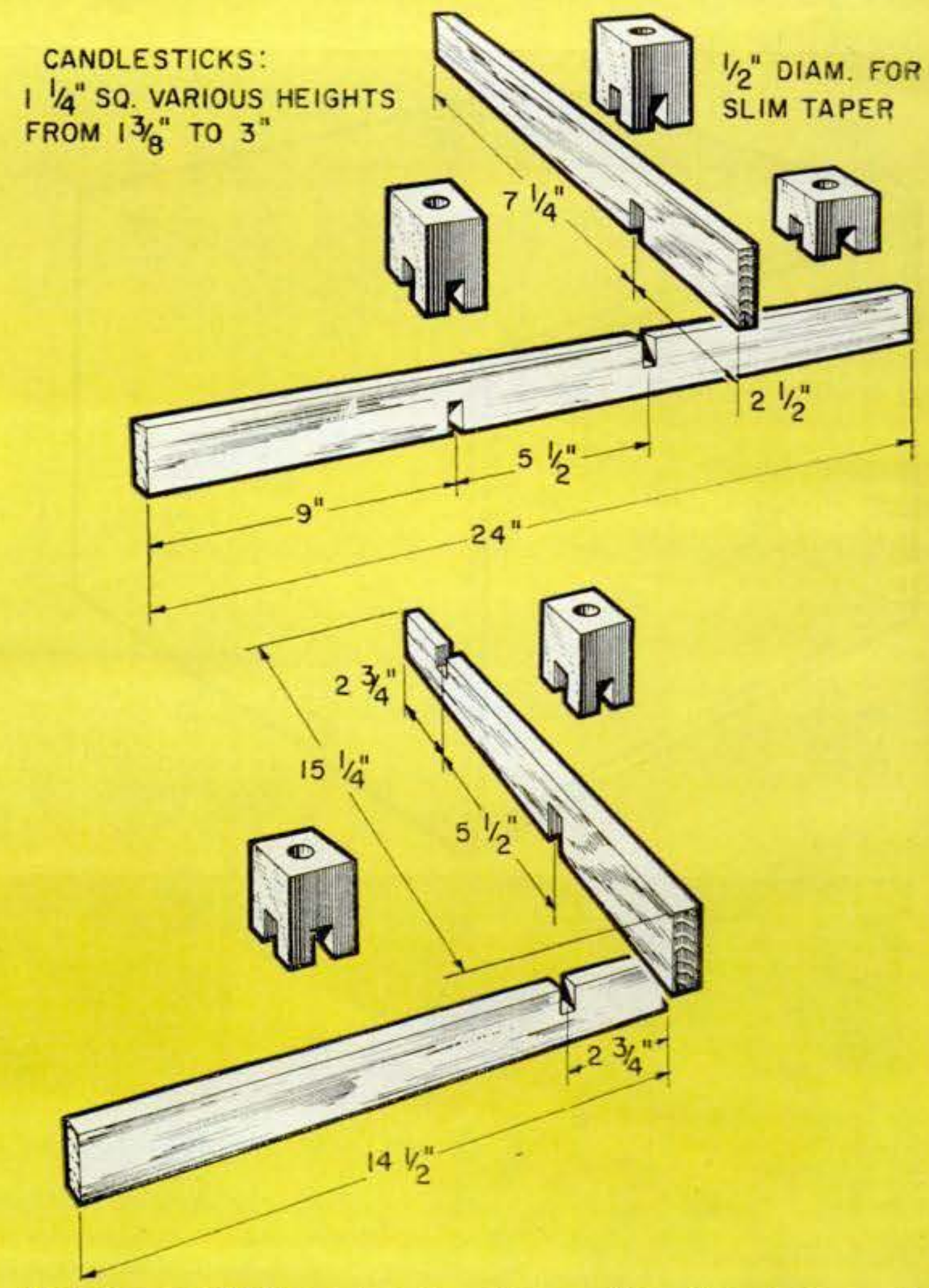
After assembly, spray cube and coasters with two coats of black paint. Paint dry? Next, trim your photos to size, then soak them in water and blot dry. Brush white glue on the backs of the prints and press them firmly in place. Let dry overnight, then spray coasters with two coats of varnish to protect them against damage from liquids.—*Robert Wortham*

Mod Mini-Candelabra

Scraps of fine cabinet wood are too valuable to throw away, too bothersome to keep around. I designed this miniature candelabra just to use a few such scraps of rosewood cluttering up my shop.

The sketch at right shows the dimensions for the piece I built, but you can easily modify the design to make use of any scraps you have on hand. Assembly is easy but make a full-size layout on paper as a guide to assure squareness during glue-up. Use epoxy at the egg-crate joints; it won't shrink and can fill in any voids if the joints fit loosely. Finish? An oil or penetrating resin gives rosewood, or any cabinet wood, a deep natural glow.—*David Warren*





Miniature candelabra takes five slim candles. The three candle holders at joints add rigidity to design when glued in place

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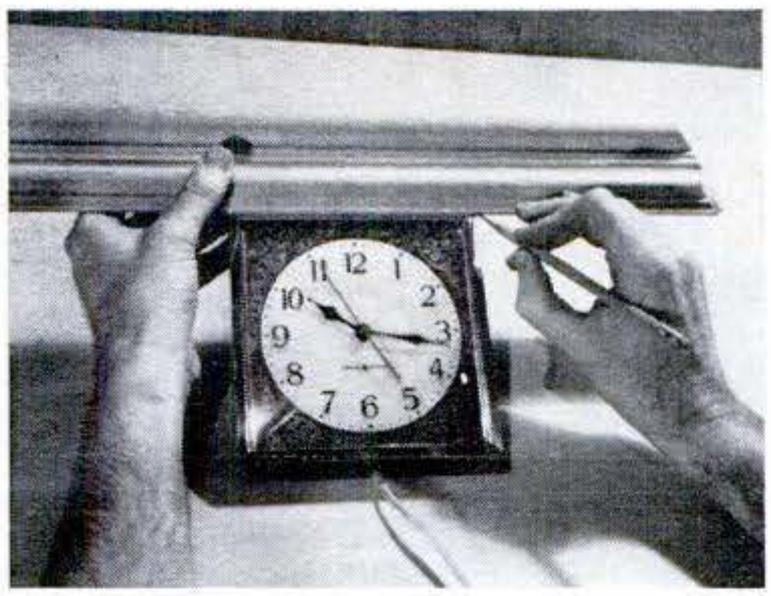
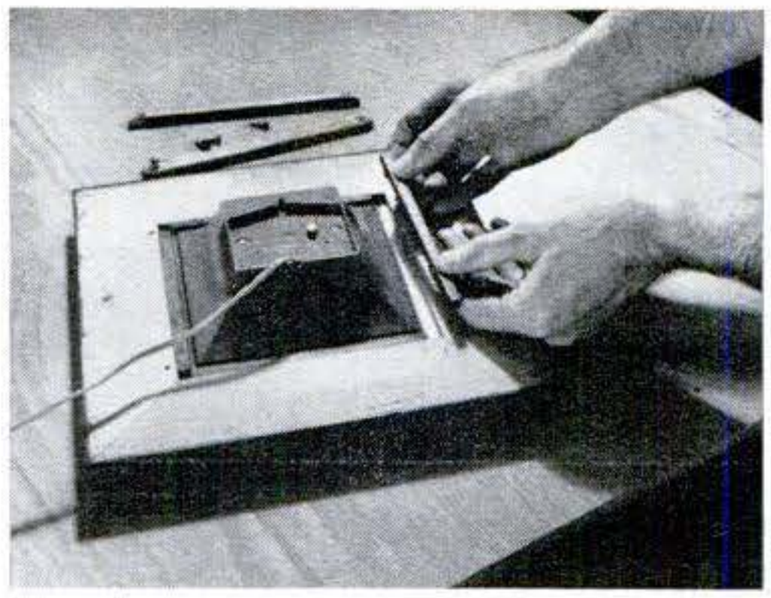
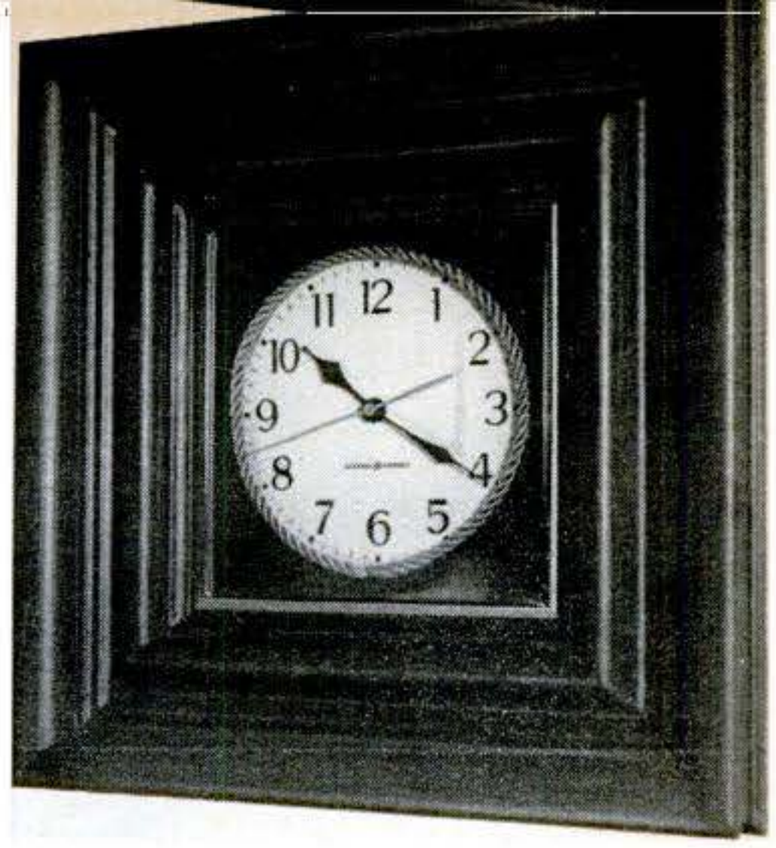
FOR YOUR HOME



Measure frame molding along edge of clock, miter cut to size and assemble. If clock has a crystal, remove and discard it.



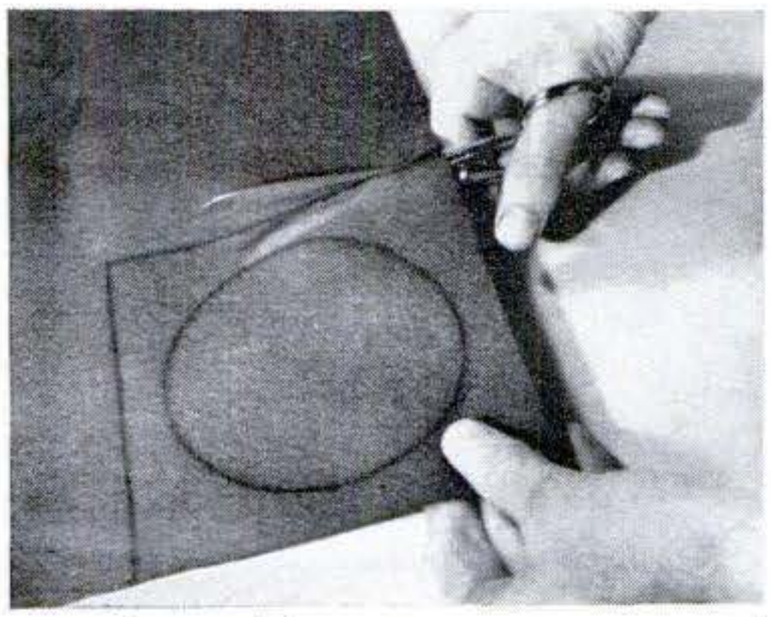
Make shims of pine to fill spaces between clock edges and frame recess, if necessary. Then secure clock with two wood strips.



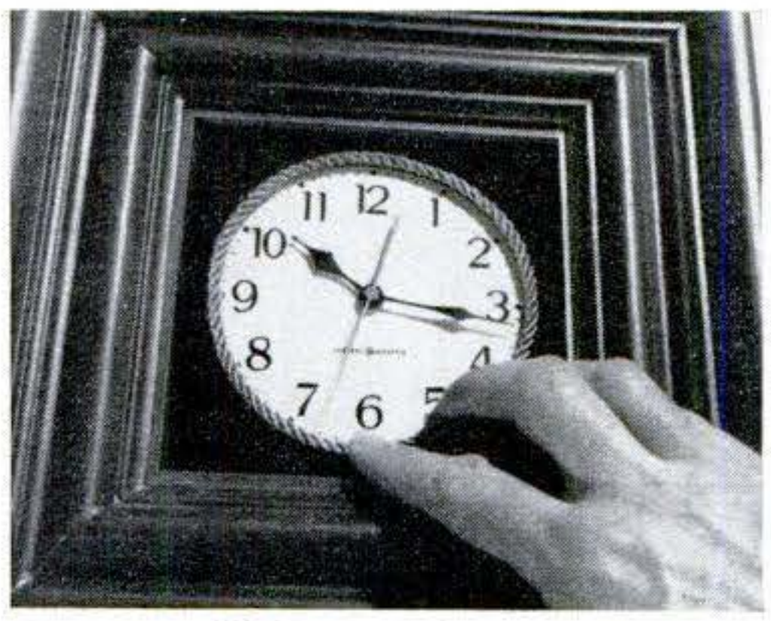
Frame Clock

A quick job of facelifting can turn an ordinary wall clock into a bold classic design that makes a fine gift, or a keepsake for your own use.

The supplies you'll need to make a frame clock are few and easy to get. Start with a square electric clock—one with a good face. I used a GE #1425 G, about $5 in department stores. Next, pick out a bold picture frame molding. At a fabric store pick up a piece of velvet or felt large enough to cover the clock face. Finally, get a strip of decorative gold trim from a drapery shop. About 14 inches should do. Got everything together? Follow the step-by-step photos at left for assembly.—*Bill Sill*



Cut velvet or felt to cover outer portion of clock face, glue fabric in place. Make circular cut carefully with sharp scissors.



Measure gold trim to make complete circle around the clock face. Fasten in place with closely spaced beads of white glue.

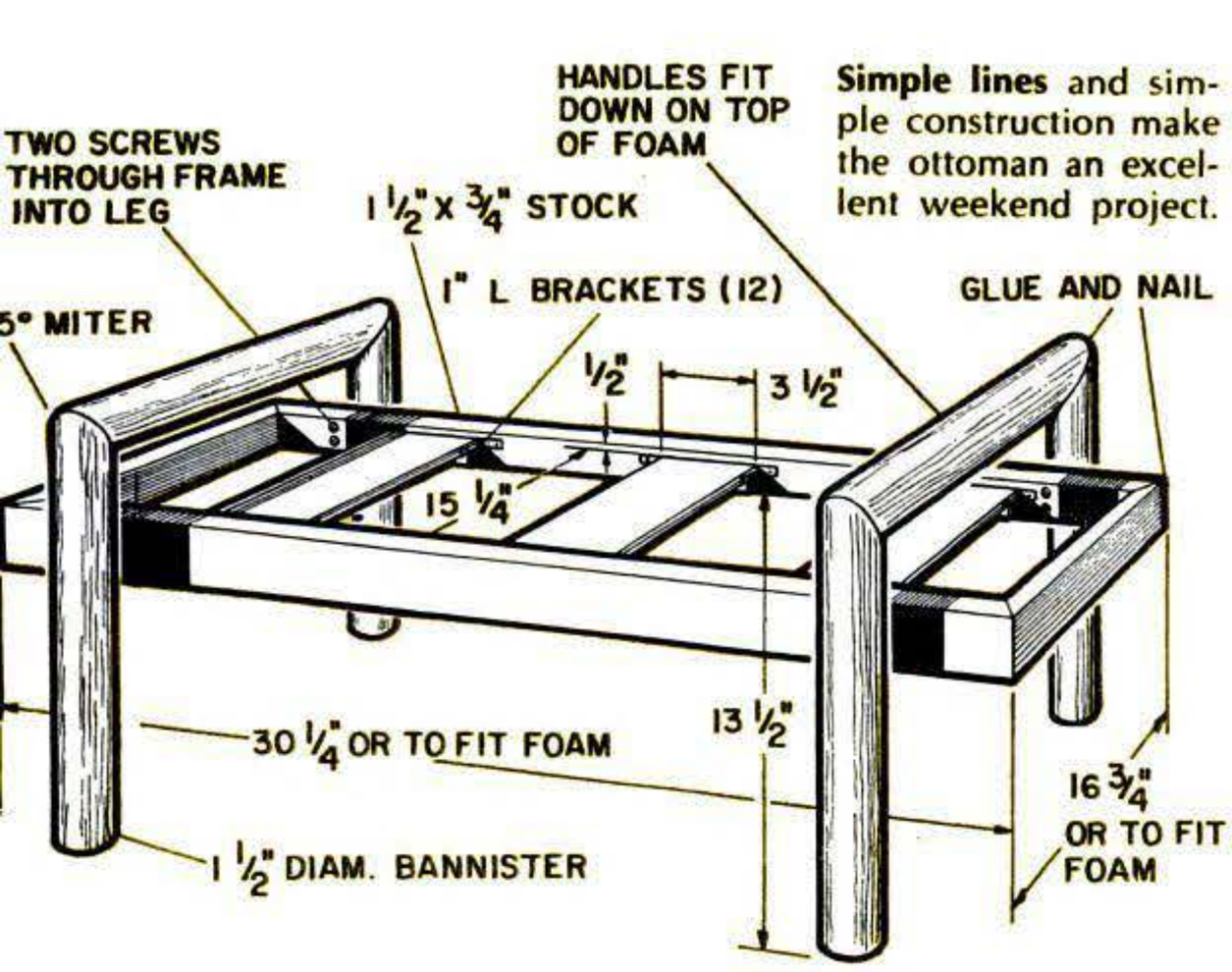
Low-Cost High-Style Ottoman

Looking for a weekend furniture project that will keep you busy but not broke? This contemporary ottoman requires no special tools or skills and costs only about 10 bucks.

Round banister stock serves for legs and handles; strips of 1″ pine make up the cushion tray. Crossbars support the cushion, giving it a flexible feel. Dimensions of the tray depend on the size of your foam cushion, so cut and cover the foam first. I used a 30″-by-15″ blank.

Pull the material tightly around the foam and sew a seam down the center of the bottom. Fold ends down and around the end of the foam and tack in place with a few stitches.

Now build the cushion frame around the foam. Position the crossbars in the frame ½″ from the top, fasten with screws and 1″ L brackets. Cut and assemble the leg-handles. Position so that handles rest on the foam. Fasten assemblies in place with screws from inside the frame, a pair at each point.—*W. J. Hawkins*



Simple lines and simple construction make the ottoman an excellent weekend project.

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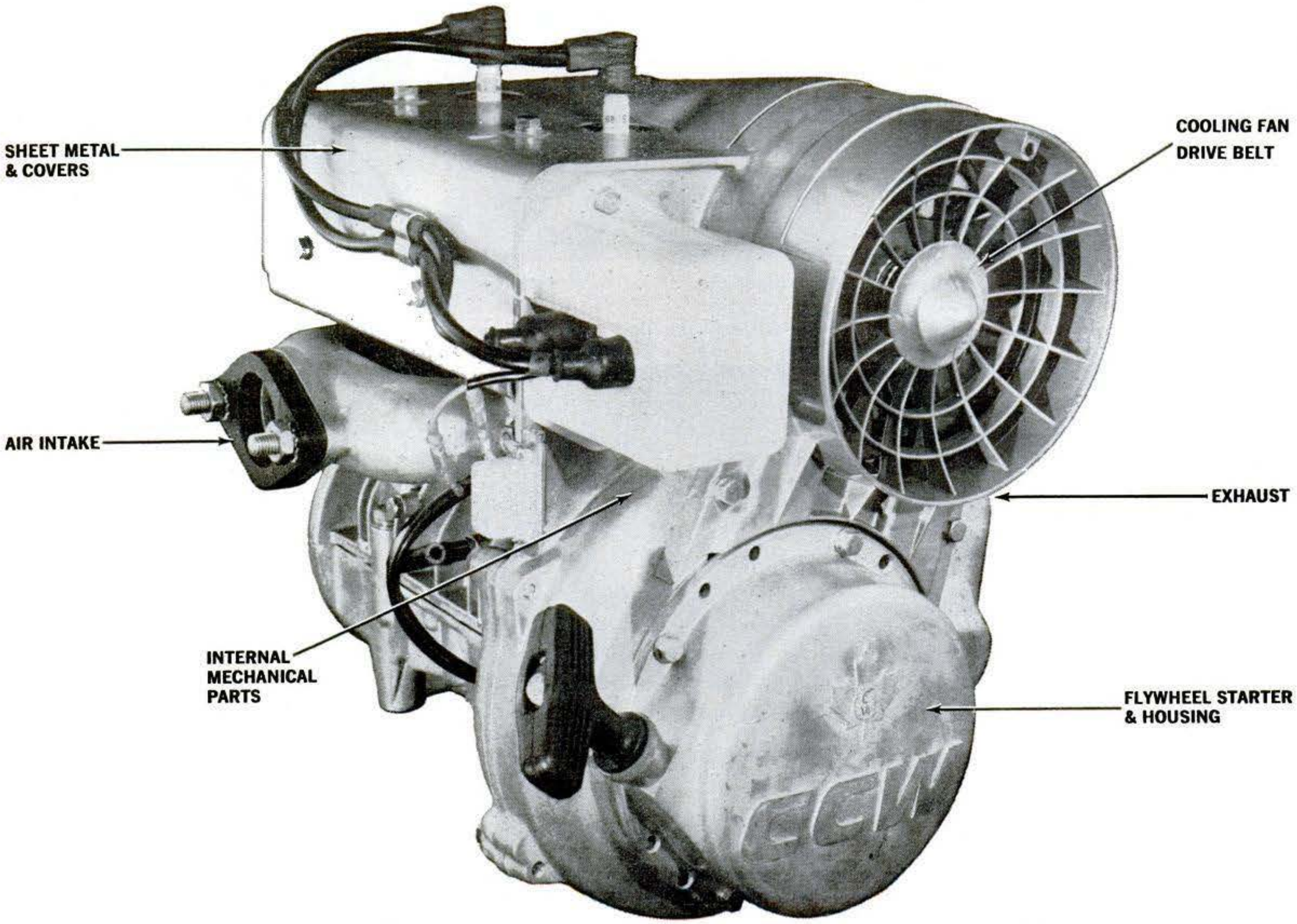
Can We Quiet Those



Small engines like this produce most noise from sources shown. They also work at a much higher proportion of their total power capability, and are without benefit of water-cooled jackets, which quiet your car engine. But even so, engines such as snowmobile power plant above will produce no more than 82 dbA by 1973. By comparison, an accelerating car reaches 85 dbA.

Engineers are making progress, but silencing motorcycles, snowmobiles, mowers, and chain saws is surprisingly tricky

By E. F. LINDSLEY / *PS Midwest Editor*

Talk about small-engine noise today and you'll have to raise your voice to be heard above your neighbor's mower, tractor, snowmobile, or chain saw. These little power plants have become so much a part of our life that most of us can't remember how we lived without them. But couldn't the awful racket they make be quieted by better mufflers? There are no easy answers.

I recently visited engine and outdoor-power-equipment manufacturers and talked to environmental specialists and research engineers to find out where they now stand on noise-reduction efforts and what we can hope for in the not-too-distant future.

All of them are increasing their efforts to make their products quieter, spurred on by an increasing body of new laws and the public outcry against noise pollution.

A Chicago noise ordinance, the toughest in the U.S., became effective last July 1. It specifies noise levels, generally measured in A-scale decibels (dbA) at 50 feet, for industrial and recreational engine-driven equipment. Other cities and states have either passed or considered such laws, or are waiting to see if a nation-wide, federal noise standard might not be a better way.

If cutting down noise were just a matter of clamping a better muffler on the exhaust pipe, a simple muffler law would suffice, and all the technical problems could be forgotten.

But muffling isn't enough. Taylor Products Div. (muffler builders) of Tecumseh Products Co., the latter one of the largest builders of small engines, brings it all down to earth with some sound readings taken according to Chicago ordinance standards. First, for a 3.5-hp rotary, walk-behind mower:

Noise at 3,225 rpm	68.0 dbA
Without metal shroud	67.0 dbA
With exhaust isolated	65.3 dbA

In short, even with engine exhaust acoustically isolated by being conducted through soundproof piping to a discharge beyond the sound pickup, the mower was hardly quiet.

Or, repeating the same test on a 12-hp garden tractor without attachments:

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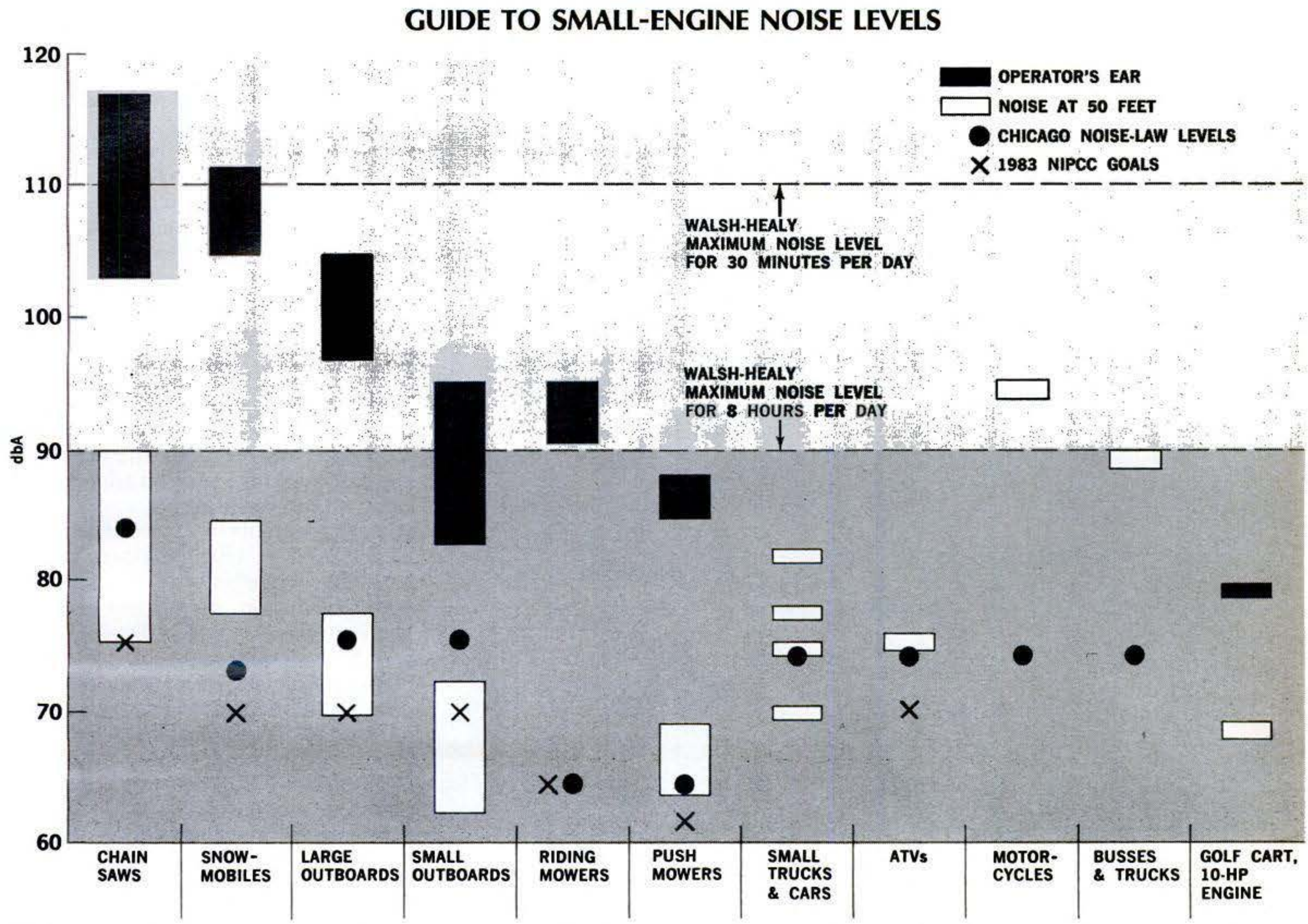
Noisy Little Engines?



How they stack up: Comparative noise levels of the most commonly used power plants are shown in relation to federal limits set by Walsh-Healy industrial-noise law. Also given are new limits set by Chicago, Ill., and goals of the National Industrial Pollution Control Council for a decade from now. Based on information from Cushman Div., Outboard Marine Corp.

Noise at 3,500 rpm 76.0 dbA
Without shrouds, covers, guards, fenders, etc. 72.5 dbA
With exhaust isolated 72.0 dbA

Here, on a larger machine, exhaust noise was even less of a factor.

Don't try to add and subtract db values as you would dollars and cents. The dbA scale is logarithmic, so a modest-sounding reduction of just a few db can indicate a large reduction in sound-pressure level.

Another builder of small four-stroke engines closely matches the above results with an eight-hp riding mower using today's standard muffler. Total reading, *without mower blades,* is 76.5 dbA; 72 dbA with an optional extra-cost muffler; and 71 dbA with a perfect muffler (isolation).

What do noise numbers mean?

- Decibels, A scale at 50 feet, is basically a selection of frequencies to which the human ear responds most acutely, measured at a distance fairly representative of a mower, cycle, or other noise source passing by. Generally, this may be considered annoyance noise—not necessarily harmful.
- Noise readings at "operator's ear," possibly harmful. Here, a sound pickup is mounted in the approximate location of the operator's ear, or at a standardized point such as eight feet from the noise source in a boat.

Harmful hearing effects. Noise of sufficient intensity and duration can cause temporary or permanent loss. Moreover, an operator bombarded by noise may be dangerously disoriented or fatigued. A driver may be unable to hear warning horns or other traffic; a chain-saw user might not hear a branch crashing down.

In general, this is an industrial problem and is being handled by federal regulations aimed primarily at workers subjected to noise on a daily basis. In such cases as racing snowmobiles, outboards, or motorcycles, ear damage is possible but is usually limited by the short duration of a driver's exposure.

If quieting the exhaust won't quiet the engine, then where does the noise come from?

Light weight and high output are basic to outdoor power, be it a fast-skimming outboard boat, a snowmobile, a chain saw, or a lawn tractor. The outboard is probably the best example of real success in quieting from earlier years, but outboards have the advantage of a noise-blocking water jacket and underwater exhaust. Even so, it took snug, soundproof covers to really quiet the outboard.

Your passenger car, with its tremendously heavy, water-jacketed, cast-iron engine, cannot be compared with a 50-pound, air-cooled engine working at a much higher load factor. Your conventional American car engine, at 60-mph cruise, is loafing

Continued

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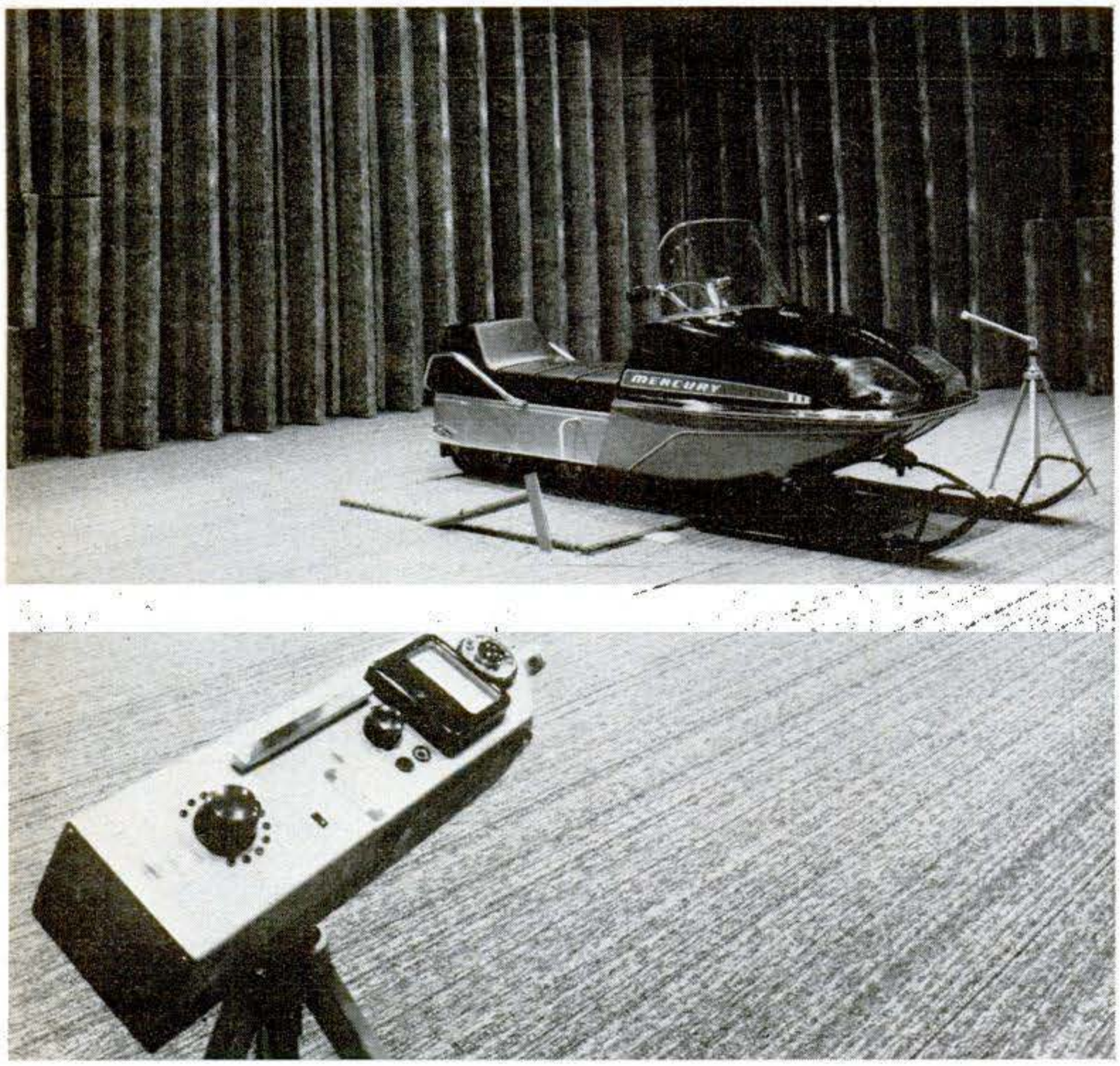
along, bundled under a fairly tight, separate engine compartment, and dampened by about 2,000 pounds of steel, rubber, and upholstery.

The price of efficiency. Your mower or snowmobile engine works at a much higher proportion of its total power capability, and is exposed to air for cooling and mounted on a relatively light substructure. Clearly, if you cared to buy a snowmobile or mower with a water-cooled cast-iron engine, four times larger than needed, with a ton of steel around it, you could enjoy the comparative quiet of a car.

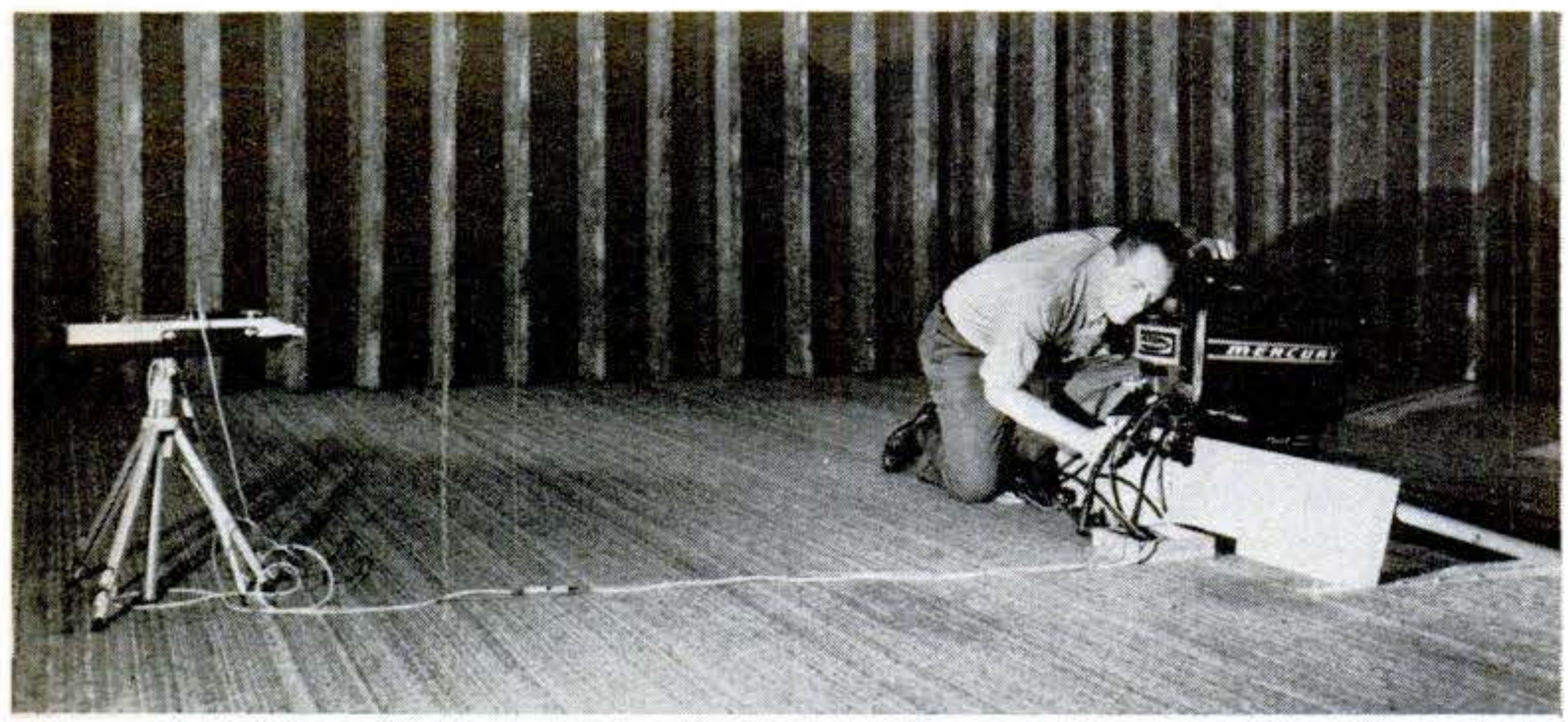
Facing facts in the real world of small engines, working to power light, nimble, inexpensive equipment, one major engine builder sums up the non-exhaust noise situation:

- Noise from the physical deflection of the engine cylinder head and associated parts goes up as the third power of the engine bore.
- Engine noise with a perfect muffler would be cut only 25 percent.
- Even with the perfect muffler you couldn't meet the projected noise levels of the Chicago ordinance.

The snowmobile makers, probably the most damned publicly, have also found that even effective muffling (not easy with two-stroke engines) helps them take steps to cut noise production from each source in the engine, running gear, and vehicle vibrations.



Anechoic chambers like this one—free from echoes and vibrations—are used by sound engineers to isolate noise sources. This



Sound produced by new 65-hp Mercury outboard, studied here by author Lindsley, was designed with the help of anechoic-chamber analyses. Result: a substantially reduced noise level. A big assist comes from soundproofing water jacket for cooling.

solves only one problem. There's still intake noise, for example.

The rapid, pulsating induction of air through the carburetor and the kickback noise from the crankcase are very audible. Mercury and Outboard Marine use reed valves partly to dampen this noise. So the next step is more-complex air cleaners. Tests by the National Research Council of Canada show that this is helpful.

Quiet? Not yet. When intake and exhaust are both blanketed, noise i reduced, but not spectacularly. George Gowing of Bombardier Engineering in discussing a snowmobile engin apart from the machine, says the picture can be: engine mechanical noise 80 db, muffler 80 db, and intake a 80 db—for an overall noise level o 85 db. He points out that eliminating both exhaust noise and intake noise would still leave 80 dbA at 50 feet.

Even if you wrapped the engine in a soundproof housing and silenced the exhaust and air intake, there are still other formidable noise sources, say Dave Phillips, chief engineer at Bo lens. These include:

- Noise from structures such a hoods, fenders, mower decks.
- Noise from driven tools—mowe blades, snow augers, tillers.
- Drive noise from chains, gears, pulleys, shafts, hydraulic pumps.

Some fascinating figures. Bolens engineers have gathered data showin biomechanical sensitivities of the hu man body, thresholds of perceptio and discomfort from varying displace ments, planes, amplitudes, and fr quencies, and how they all relate power-equipment vibrations.

Suffice it to say that single-cylin engines, especially noncounterb anced drive shafts and other rot parts, are inherently capable of ing noise and discomfort. A machine may be driven by an silent electric motor and still the acceptable noise levels. The ways, of course, to minimize t

- Limit displacement velocit
- Hold close balance toleranc all rotating parts.
- Change ratios so rotating par are below or above unfavorable are
- Isolate vibration sources by fl ible mounts and spacers.
- Use counterbalanced or two-cy inder engines.

The cost of noise reduction will come out of your pocket when yo buy a new mower, tractor, or snow mobile. Right now, major manufac turers peg the price boost at 10 to 30 percent over the equivalent machine with current noise levels. Moreover, noise reduction will increase complication, make service more costly and less convenient, and probably increase weight and bulk. PS

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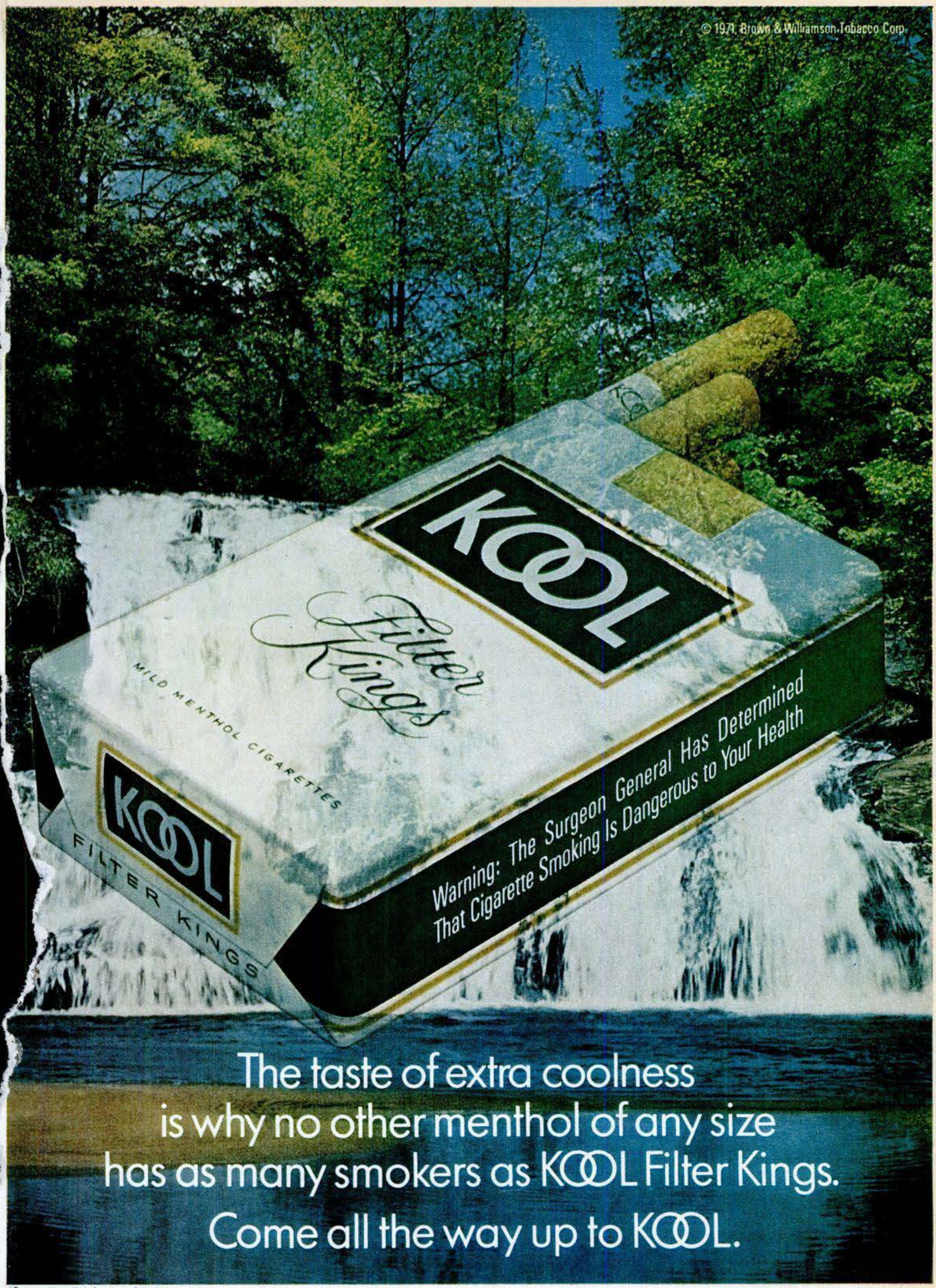

18 mg. "tar," 1.4 mg. nicotine
av. per cigarette, FTC Report Aug. 71.

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Don't play winter roulette. Know the condition of your battery, before it's too late, with this—

Battery Tester for Your Car

By RONALD M. BENREY

Cold weather is with us, and Jack Frost usually finds a way to boggle some automotive part at just the moment you need your car most. Your storage battery is one of the most common cold-weather victims. A slow grinding start, a familiar clicking under the hood, or that deafening silence as you turn the key is your battery telling you it's in trouble.

Generally, however, your battery doesn't go dead all at once. It's a relatively slow process in which the cold weather just acts as a catalyst. And here's where the tester comes in.

What will it do for you? Performing this quick, but highly accurate, voltage test on your battery every so often during the winter months can tell you a great deal about the status of your battery and how good your chances are for a quick start in the morning.

The test is used to indicate the condition of the positive and negative plates inside the cell.

It would be impossible, however, to run an individual cell test on your car battery, since there is no access to the individual cell terminals on modern batteries. But, it *is* possible to do a kind of "back-to-back" cell test—between the electrolytes of adjacent cells.

This test simultaneously monitors the condition of the positive plate in one cell, and the negative plate in the adjacent cell. By taking a string of adjacent cell readings and comparing the results, you'll find that any weakness of your battery will be quickly apparent.

The battery tester is designed to perform such a test. It is a simple —but very accurate—potentiometric-type voltmeter that will measure the voltage between two cadmium electrodes that are dipped into the electrolytes of adjacent cells in any lead-acid battery. You can read the voltage with a resolution of 1/100 vol

Use it faithfully, and the devi will quickly point out inconsistenc within the battery that indicate c ing failure, or at the least, redu performance. And, it will help y to determine whether a battery t has been badly serviced, or abus has been damaged.

How it works. Cadmium met rods are difficult to come by, so our tester uses cadmium-plated brass spacers as electrodes. These are readily available from electronics part houses. Do *not* substitute nickel- or zinc-plated hardware.

The voltmeter is a bridge-type circuit that is very accurate. It is calibrated so that "0" on the vernier dial corresponds to an input of 1.5 volts DC, and the "100" reading equals 2.5 volts DC. The vernier then covers a linear range of one volt with 100 scale dimensions—each step equal to 1/100 volt.

When the electrodes are immersed

Continued

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Evinrude Firepower Ignition performs like a permanent tune-up.

Firepower is the newest of all the electronic ignition systems.

It delivers a high-intensity 40,000 volt spark — 400 times faster than conventional systems. Does it without breaker points and without wearing mechanical parts.

Firepower uses new surface gap spark plugs with tough tungsten-alloy electrodes that last far longer than ordinary spark plugs.

All this means quicker starting, faster acceleration, better trolling, and more consistent top speed.

It also means your 1972 Evinrude motor with Firepower ignition will keep its original factory ignition timing — almost indefinitely.

And it will retain its clean-burning combustion and remarkable fuel efficiency far longer.

So long sparkless plugs! Evinrude Firepower ignition is here. Now. At your Evinrude dealer.

Free color catalog. Send your name on a postcard to Evinrude Motors, 4038 N. 27th St., Milwaukee, Wis. 53216.

CLEAN WATER: *our future is riding on it* **EVINRUDE** *first in outboards*

Div. of Outboard Marine Corp., makers of OMC Stern Drives

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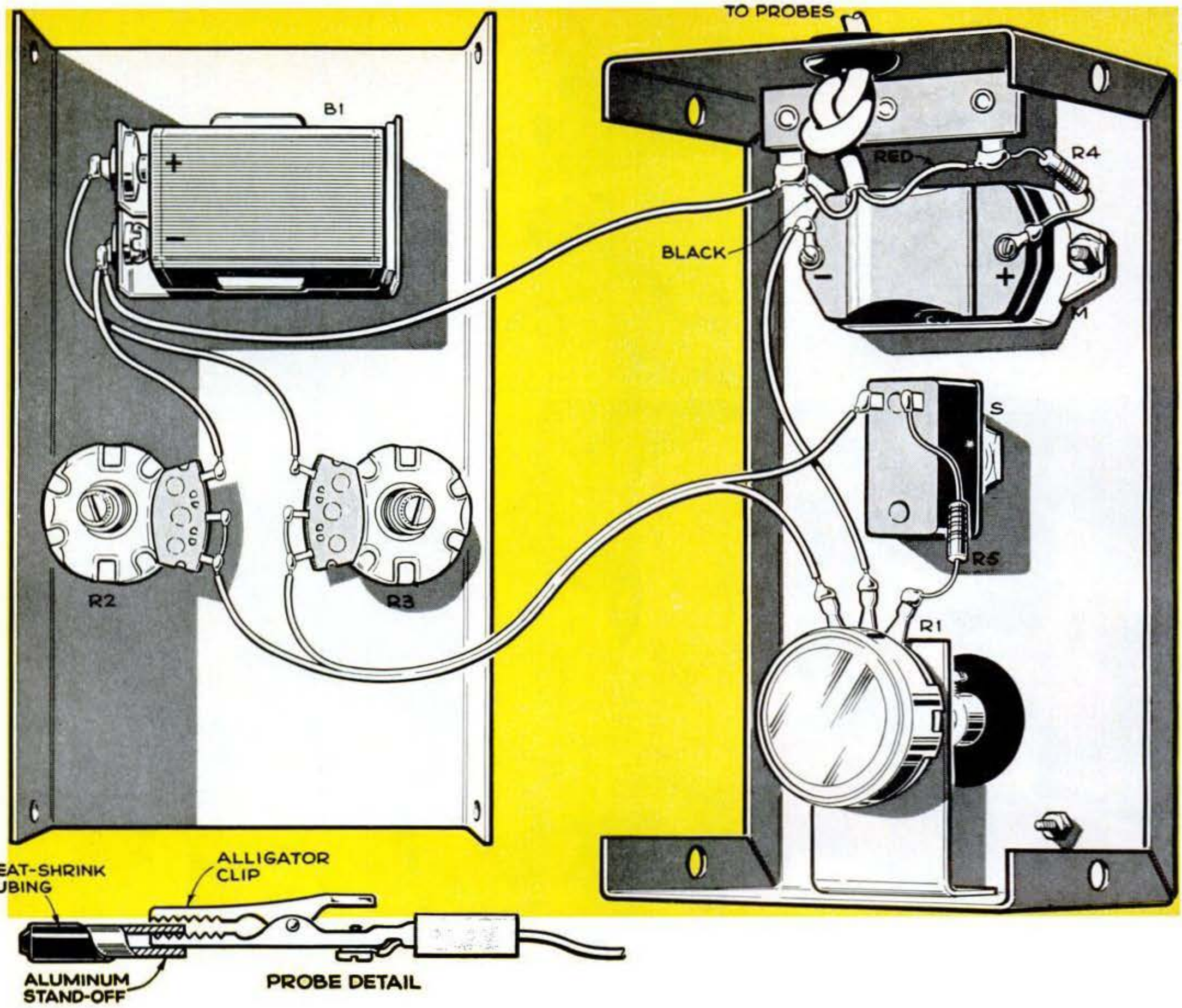


in the electrolytes, the voltage between them is applied to one side of the "zero center" meter movement. You then adjust potentiometer R1 (by turning the vernier dial knob) until the voltage across its wiper balances out the electrode voltage. When this happens, the meter needle rests at dead center. You then read the voltage off the vernier dial scale and add 1.5 to get the cadmium voltage. You should find most of your readings in the vicinity of two volts.

Building it. The simple circuit fits neatly into the 5"-by-2"-by-3" aluminum minibox specified. Mount the vernier dial on the faceplate as shown and center R1 just behind it on a scrap piece of aluminum.

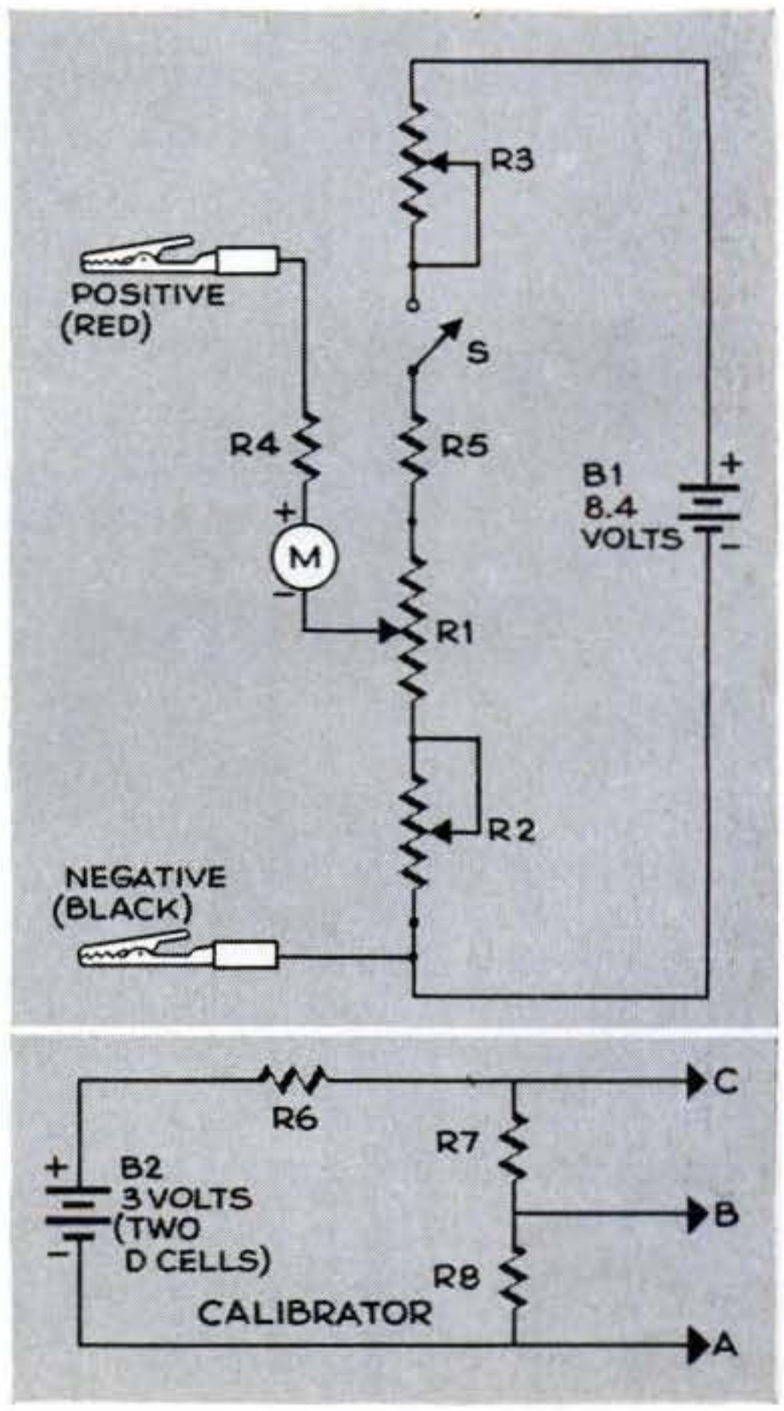
Cut the shaft to the proper length and pass it through the bushing hole into the rear of the vernier dial. Before you tighten the bushing setscrew, turn the vernier to read "100" on the dial and turn the shaft of R1 fully clockwise. This insures readings on the vernier in step with the turning of the potentiometer.

Cement the two calibration potentiometers R2 and R3 in place with dabs of contact cement. Be careful that you get no cement inside the bodies.

The test lead is a length of two-conductor cable terminated by a pair of colored (one red, one black) alligator clips.

Make the cadmium electrodes by covering the cadmium-plated spacers with shrink-fit tubing. (This is a plastic tubing that shrinks to half its original diameter when heated.) Insert each spacer in a short length of

[*Continued on page 117*]



PARTS LIST

R1—1,000-ohm, linear-taper, carbon potentiometer
R2—2,000-ohm, linear-taper, carbon potentiometer
R3—5,000-ohm, linear-taper, carbon potentiometer
R4—1,000-ohm, ½w carbon resistor
R5—2,200-ohm, ½w carbon resistor
R6—100-ohm precision resistor (see text)
R7—200-ohm precision resistor (see text)
R8—300-ohm precision resistor (see text)
M—zero center tuning meter (Lafayette 99 F50346)
S—SPST toggle switch
Battery: 8.4-volt mercury battery (Mallory TR-164X or equal)
Misc.: Aluminum 5"-by-2"-by-3" minibox; 1½" vernier dial; alligator clips; cadmium-plated brass spacers (H. H. Smith 2104 or equal); ½" o.d. shrink-fit tubing

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We've canvassed campers and they're solidly against canvas

If there's one thing most people dislike about camping, it's canvas. It can tear, shrink, fade and mildew. And be generally difficult to work with. That's why Apache developed Solid State . . . the camper that has everything. Except canvas. Instead, Apache has solid walls, solid roof and solid bedrooms, made of rugged ABS thermoplastic. It's the greatest thing to happen to folding camping trailers since Vesely Company pioneered the Apache back in 1957. Solid State means more comfort, more protection, more years of useful trailer life. Inside there's solid beauty, with fully draped walls and a choice of two different interior color combinations. The price is right, too . . . for the Mesa model, shown here, and seven other Solid State Apaches for '72. For the name of your nearest Apache dealer, check the Yellow Pages under "Trailers—Camping and Travel." Vesely Company, Box 420, Lapeer, Michigan 48446.

Wheel discs are extra-cost accessories.

APACHE® VESELY COMPANY

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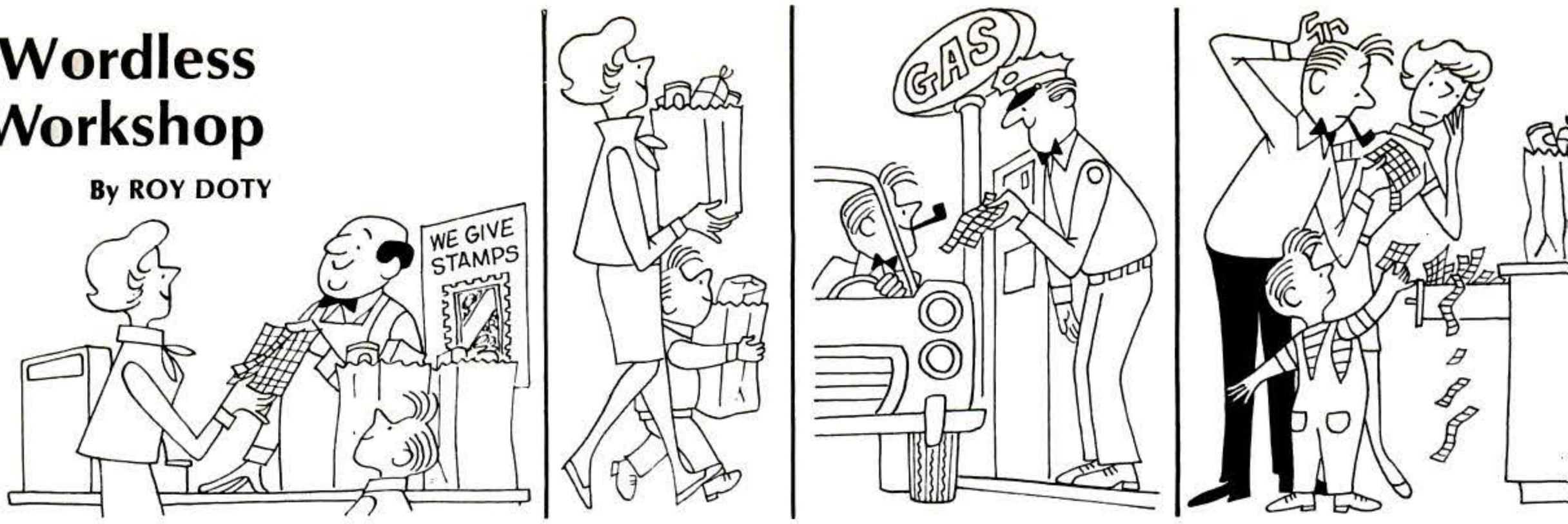
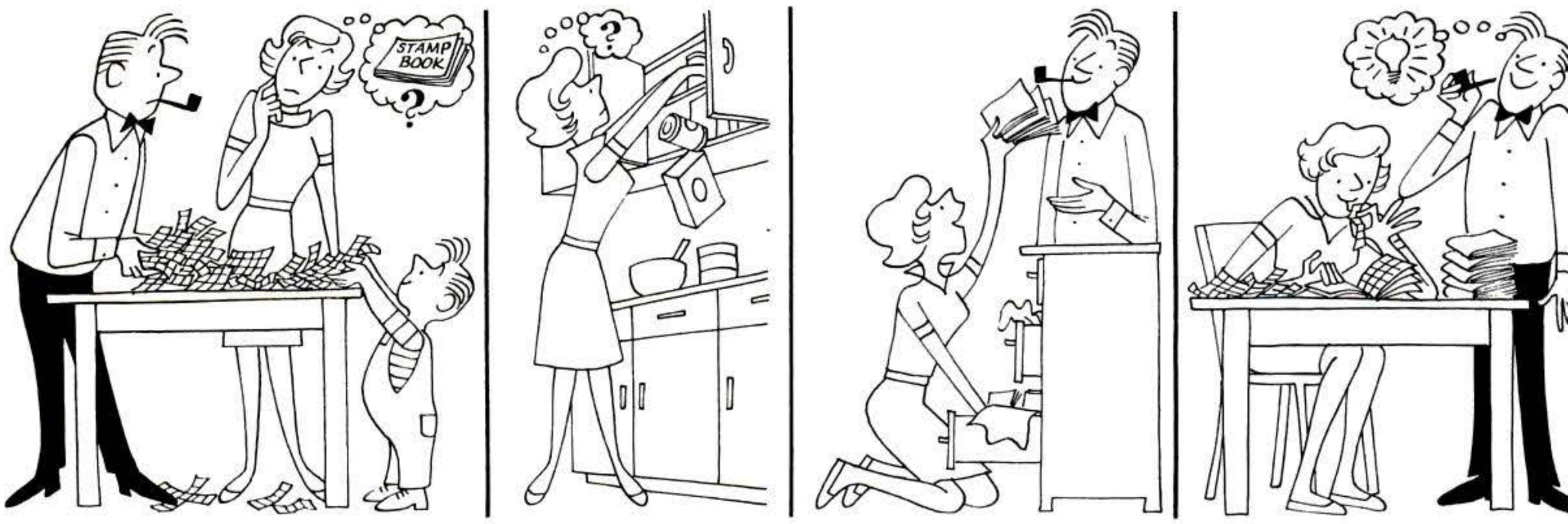
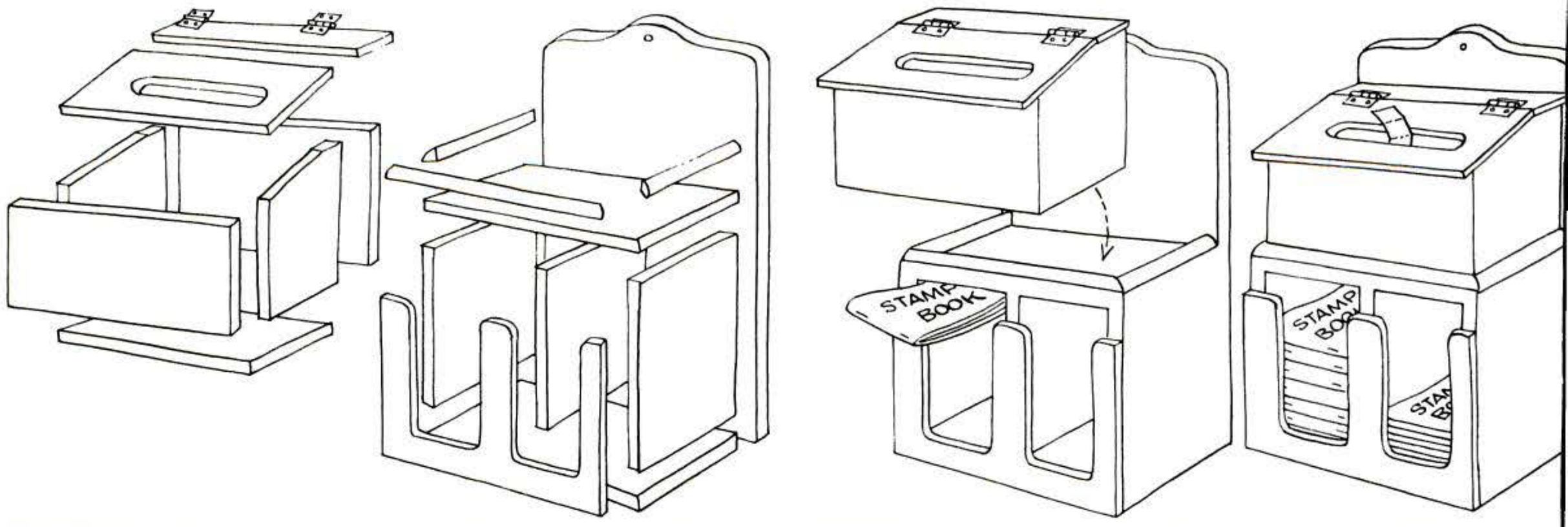
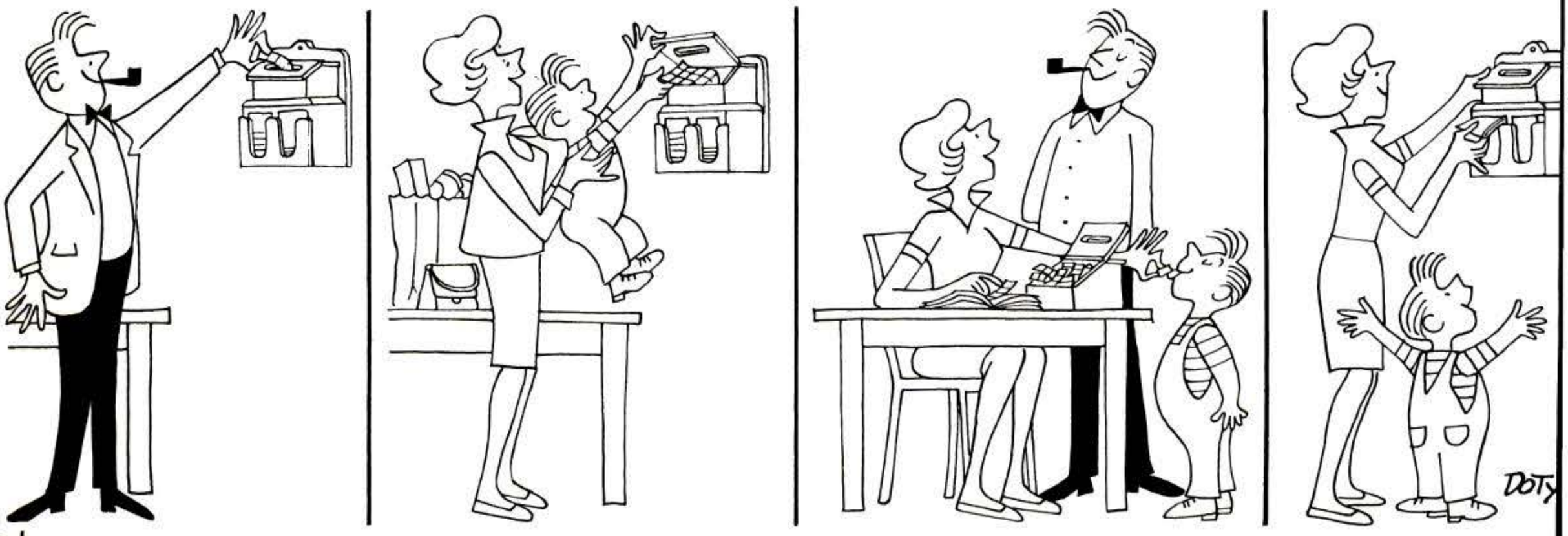
Wordless Workshop

By ROY DOTY









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Battery Tester for Your Car

[Continued from page 114]

tubing (flush on one end; with a 1/16" overhang on the other), then run a match or candle flame along the tubing's surface.

This design makes the inside surface of the spacer the "active area" —the little lip formed by the 1/16" of tubing overhang serves as an insulator that keeps the spacers from touching the battery plates when they are dipped in the electrolyte.

To connect the tester to the electrodes, simply clip the alligator clips to the flush-tubing ends of the spacers.

To adapt the tester to monitor different kinds of batteries, make several sets of electrodes—each using different-length spacers to fit the filler holes of various batteries.

The calibration: For this, you'll need the simple calibrator circuit shown in the schematic. Be sure that the three resistors are all one-percent-tolerance precision units, and that the two dry-cells are fresh. Calibration is a multistep procedure:

1) Connect the negative (black) alligator clip to point A on the calibrator, and turn on the tester.
2) Set R2 and R3 to midrotation.
3) Connect the positive (red) alligator clip to B on your calibrator.
4) Set the vernier dial to zero.
5) Adjust R2 to center the meter needle.
6) Connect the positive clip (red) to point C on the calibrator.
7) Set the vernier dial to 100.
8) Adjust R3 to center the meter needle.
9) Repeat steps 3 through 8 *several* times to perfect the calibration.

Using the tester. It will read cadmium voltages between *adjacent* electrolyte holes. The positive electrode (red clip) always goes in the hole nearer the positive terminal of the battery; the negative electrode (black clip) goes in the hole nearer the battery's negative terminal.

Simply drop the electrodes in the holes so that the metal contacts the electrolyte. Don't let the alligator clips touch the solution, and *be careful* not to splash any electrolyte on your hands or face—it is a powerful acid. Rinse off the electrodes when you finish making a test.

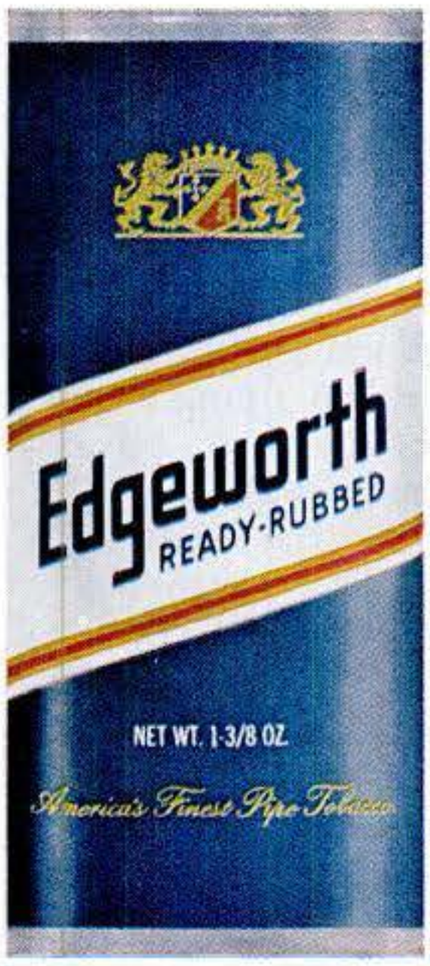
The voltage values you will read—five for a 12-volt battery; two for a six-volt unit—are related to the state of charge of the battery (whether it is being charged or discharged as you take a reading) as well as the condition of its plates.

The important thing is that the readings you get be uniform, cell pair to cell pair. This is the mark of a good battery. When a battery begins to fail, it rarely goes all at once: One cell at a time begins to deteriorate.

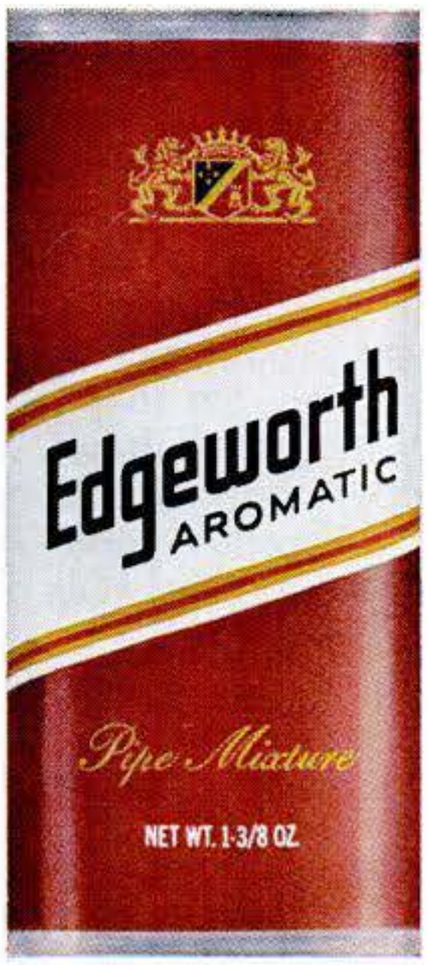
Reading differences greater than 1/10-volt (10 vernier divisions) indicate trouble is brewing.

I routinely test the batteries in my two family cars every three months. And I throw in an extra test any time I suspect that a battery may have been damaged by overcharging or lack of topping up. PS

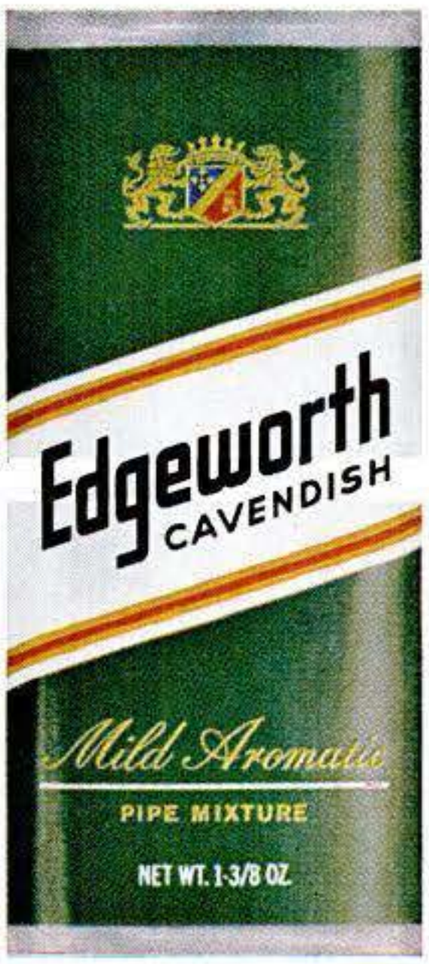
POPULAR SCIENCE



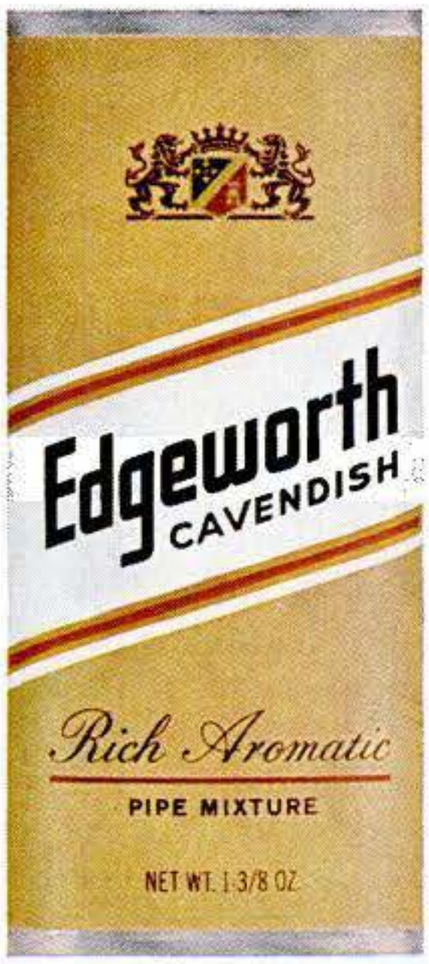
EDGEWORTH BLUE.
Edgeworth Ready Rubbed is a blend of the finest Burleys grown, chunky cut for a cooler, longer smoke.



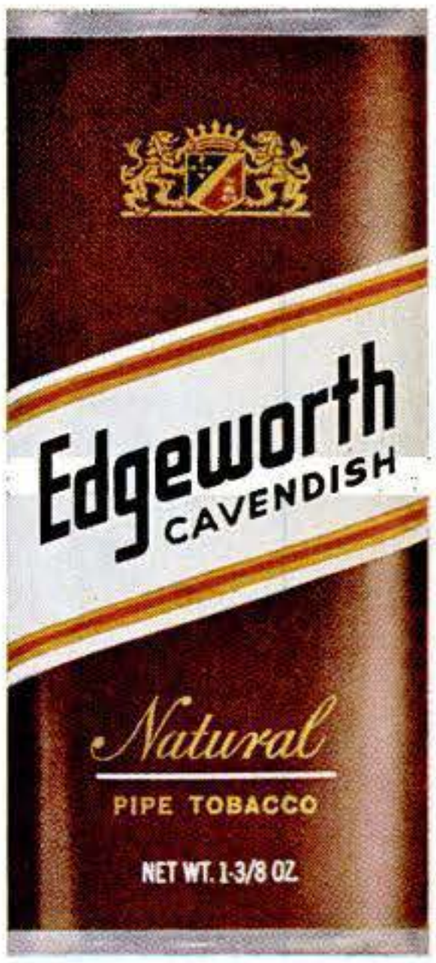
NEW EDGEWORTH RED.
A blend of Burleys and Buttery Bright Flake, toned for aroma by Latakia, Perique, and oriental leaf.



NEW EDGEWORTH GREEN.
A natural aromatic blend laced with exotic orchid bean flavor. Cavendish cut for coolness.



NEW EDGEWORTH GOLD.
Unique Cavendish cut blend with caramel nut flavoring and a dressing of Algerian rose.



NEW EDGEWORTH BROWN.
A hearty blend lightly flavored with genuine hickory smoke, cut Cavendish for cooler smoking.

Who says great pipe tobacco has to be imported at a fancy price?

Introducing the new Edgeworth Family made in Richmond, Virginia. World famous quality - duty free.

HOUSE OF EDGEWORTH
RICHMOND, VIRGINIA
America's Largest Exporters of Smoking Tobaccos.

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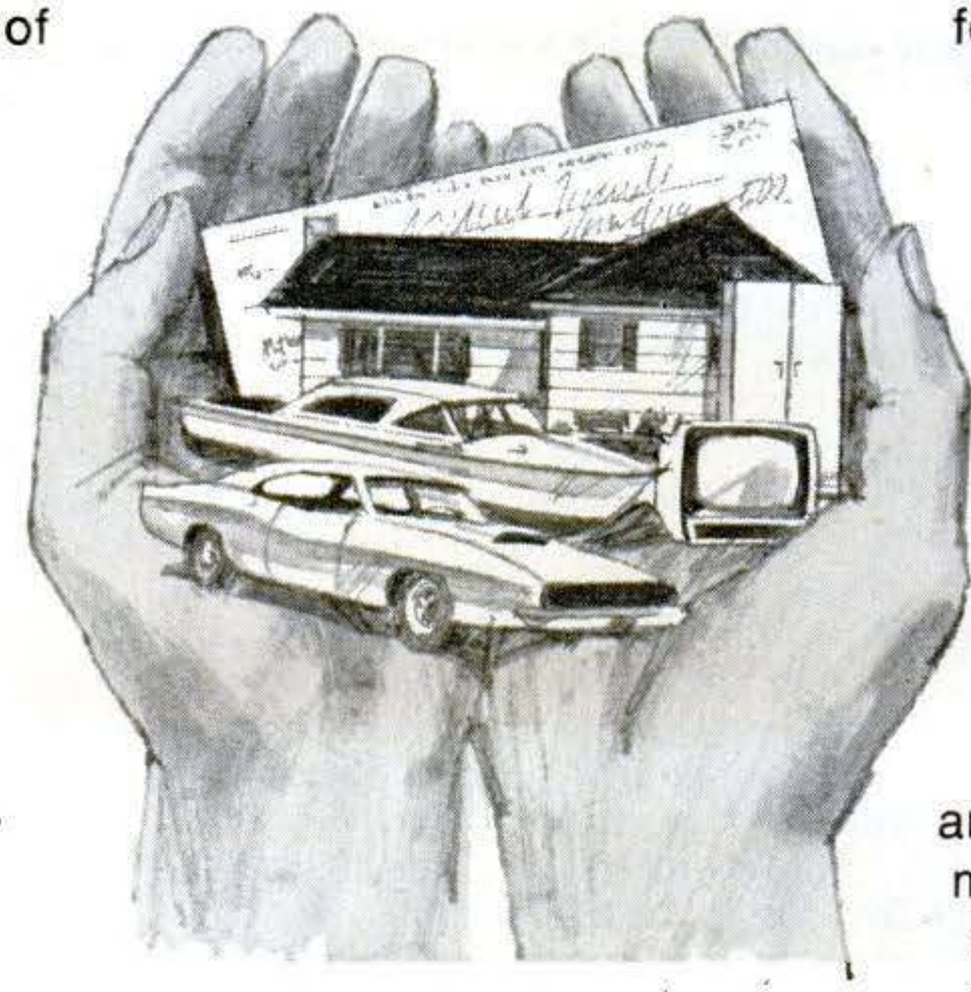

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The cost? Very little—a wise investment in security and happiness. The cost of most courses is about the same as a carton of cigarettes a week.

Getting High on Hot Air

[Continued from page 89]

some reason the burners go out and can't be relit? The balloon would fall—but, Bob assured me, air ramming up into the balloon's throat would keep the balloon's descent at about the same rate as that of a man descending under a parachute.

We level off. At 200 feet, we drifted along, looking for a landing spot. We passed over a trailer park and lots of houses. When people looked up we shouted down a "good morning," and they waved and stood gaping, crook-necked, until we drifted from sight. We floated over a highway and near a field. The wind was too strong to land safely near the road, and we didn't pass over the field—so they might as well have been a thousand miles away.

Ahead stood a wooded hill. Bob opened the blast valve and we floated majestically up and over. To our left we could now see an open space, some trees, and a town. Unfortunately, we weren't headed that way. Then suddenly the wind changed and the open area was dead ahead.

Bob pulled a line that opened the maneuvering vent—a slit high on the side of the balloon that can be opened to dump a volume of heated air, which is immediately replaced by ambient air. The result is a loss of lift and an almost immediate descent.

Yipes! We had descended a bit too much—and directly in our path was a 40-foot elm tree. I grabbed the edge of the gondola and held on.

We slammed into the top of the tree and stopped! The balloon, however, kept moving forward with its 56,000 cubic feet of hot air. Abruptly the basket was jerked free of the tree like a paper wad shot from a rubber band. We swung out ahead of the envelope and hit the ground, immediately bouncing up in the air. Drifting 20 feet, we hit again.

This time, Bob pulled a line opening the top of the balloon, spilling the air out. The balloon quickly collapsed, and there we were—standing in a little basket in the woods with a flattened nylon bag beside us.

We walked into town, and found we were in Ludlow, Mass. A call to the airport brought Bob's truck over to pick up the balloon and us. We had landed about 20 miles from our starting point. Our total time in the air was one hour and 45 minutes—all of it under a bag of hot air.

Why hot air instead of helium? Money. The cost of flying the S-50 for four hours is under $10. More than a thousand dollars' worth of helium would be required for an equivalent gas-balloon flight.

Set to go? Although flying a hot-air balloon is inexpensive, buying one isn't. Depending on the size of what you're eyeing, the price will run between $3,000 and $10,000! Envelope size ranges from 33,000 to 105,000 cubic feet of air capacity. You can get a balloon that'll carry only one person, or as many as four (including the pilot).

The three major balloon makers are Raven Industries, Box 1007, Sioux Falls, S.D.; Piccard Balloons, Box 1902, Newport Beach, Calif.; and Semco Balloons, Rt. 3, Box 678 E., Coeur d'Alene, Idaho.

The cheapest and easiest way to get high on hot air is to form a club. Buy the balloon as a group. Then attend an authorized balloon school to get your pilot's license.

You can find out where the nearest school is located and obtain more information about ballooning, too, by writing to the Balloon Federation of America, Suite 610, 806 Fifteenth St. N.W., Washington, D.C. PS

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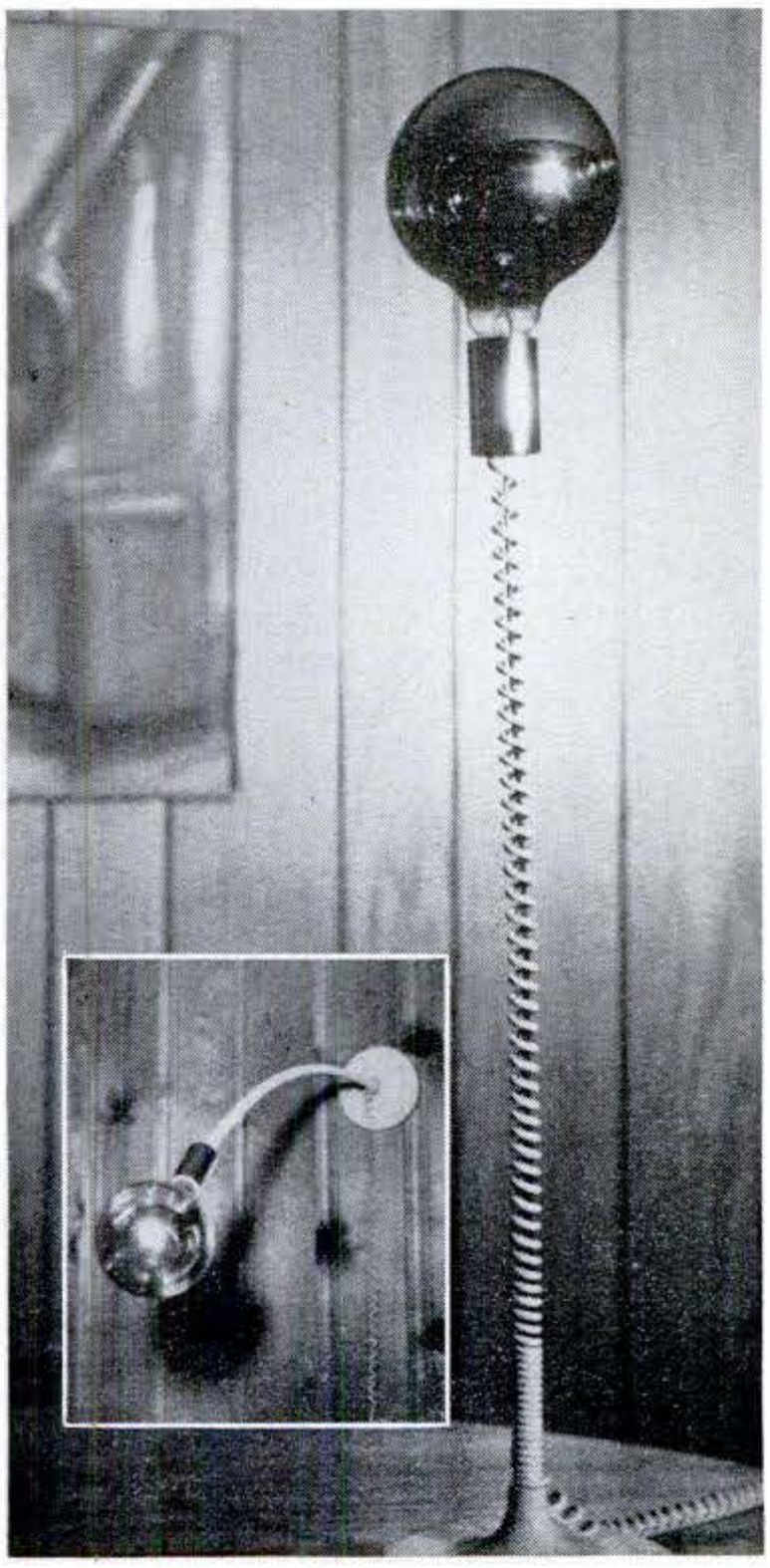
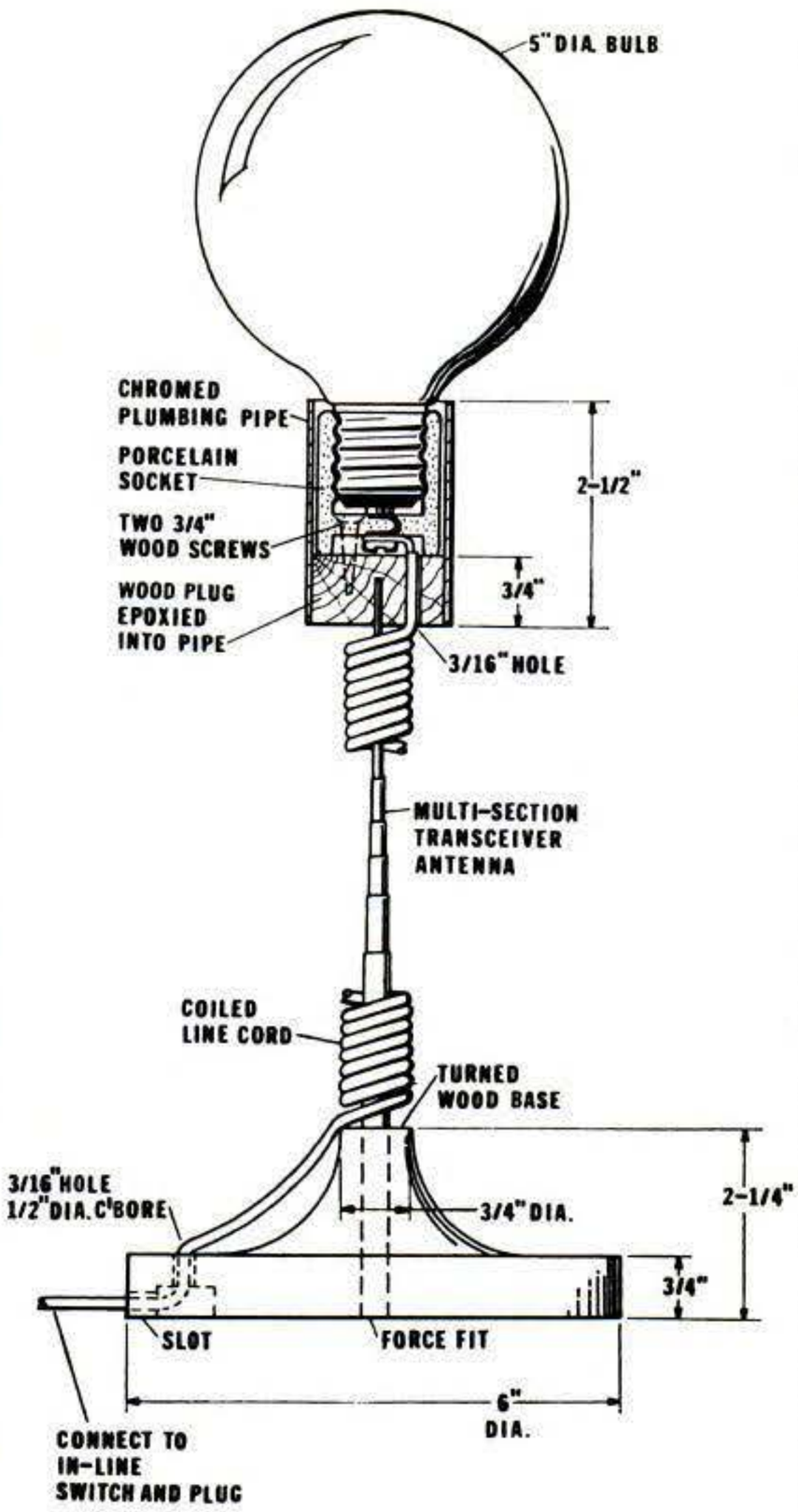


Table lamp or wall lamp—this design works either way. Hang it from the ceiling, too.



Telescoping Three-Way Lamp

Stand it on a table, hang it from the ceiling, or droop it from a wall. This modern lamp goes anywhere to add a soft glow of accent lighting to your home. You make it from a telescoping antenna so it can adjust from 20 to 40 inches in overall length.

Construction takes just a few hours and about $10 worth of parts. The design is based on a multi-section transceiver antenna (about $2), a white audio coiled cable (about $1.50), and a five-inch, 25-watt Tovibulb. Turned off, the bulb looks like a solid silver globe. Turned on, it gives a soft glow and reveals the elaborate filament inside. You can get one in silver (at $5.60) or gold ($11), from Tovi and Perkins, 292 5th Ave., New York, N.Y. Specify 25 watts. Similar bulbs in clear, smoked, frosted, and tinted glass are made by Durolite for $2.50.

The sketch shows you how to put the lamp together. If you want a strong, stiff lamp, cut a section or two off the antenna tip. For a longer and more flexible lamp, just snip off the tip ball with a pair of wire cutters.—*Phil Bowie*

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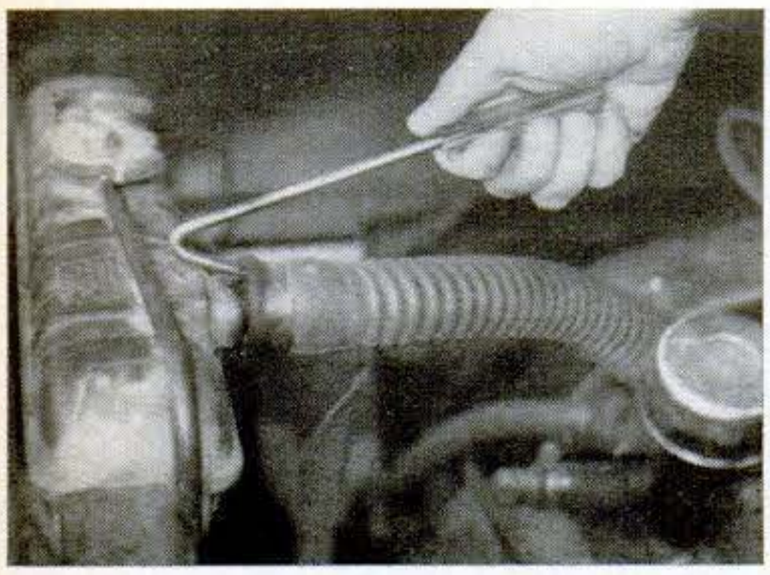
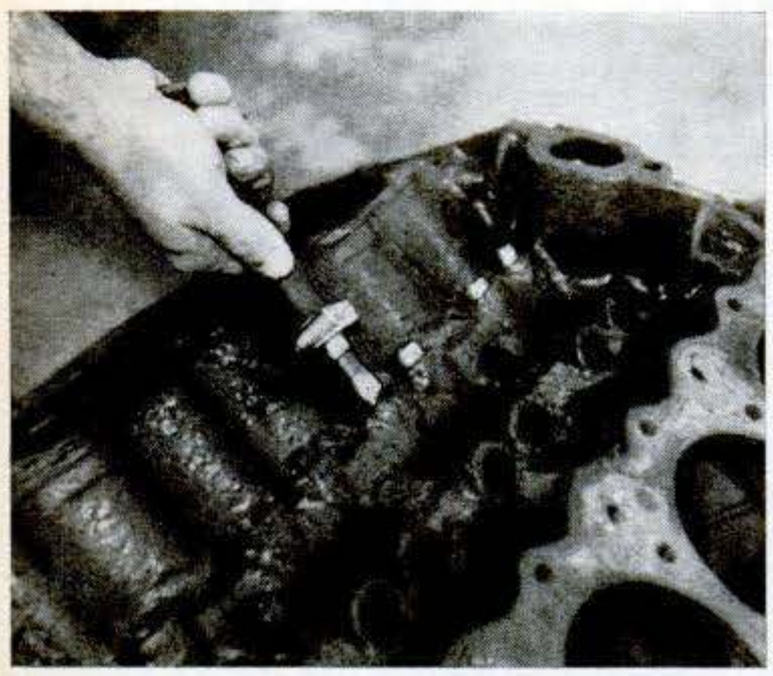
Taking Care of Your Car

Good hints others have used

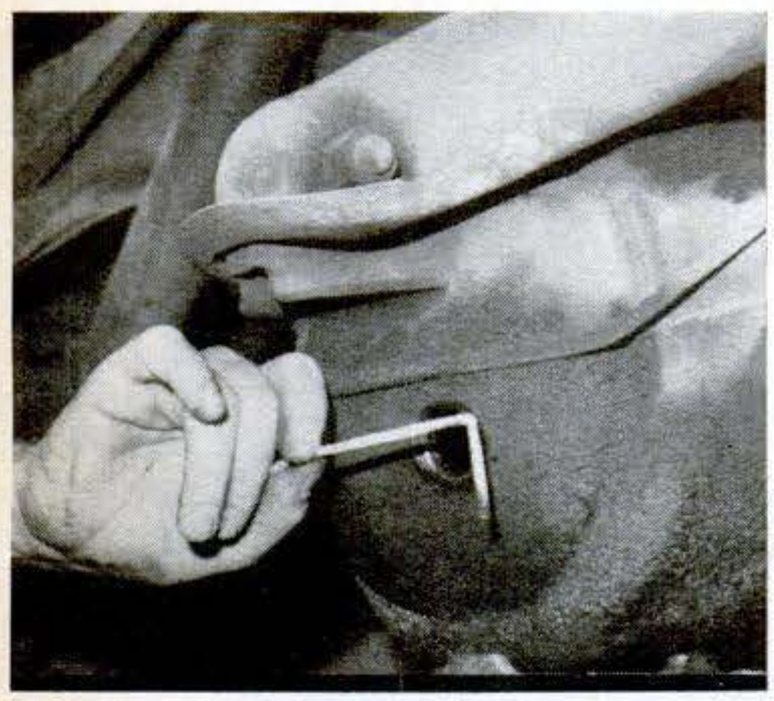
Got a car tip? We pay $25 for each one accepted. Send it to Car Care, Popular Science, 355 Lexington Ave., New York, N.Y. 10017. None are returnable.



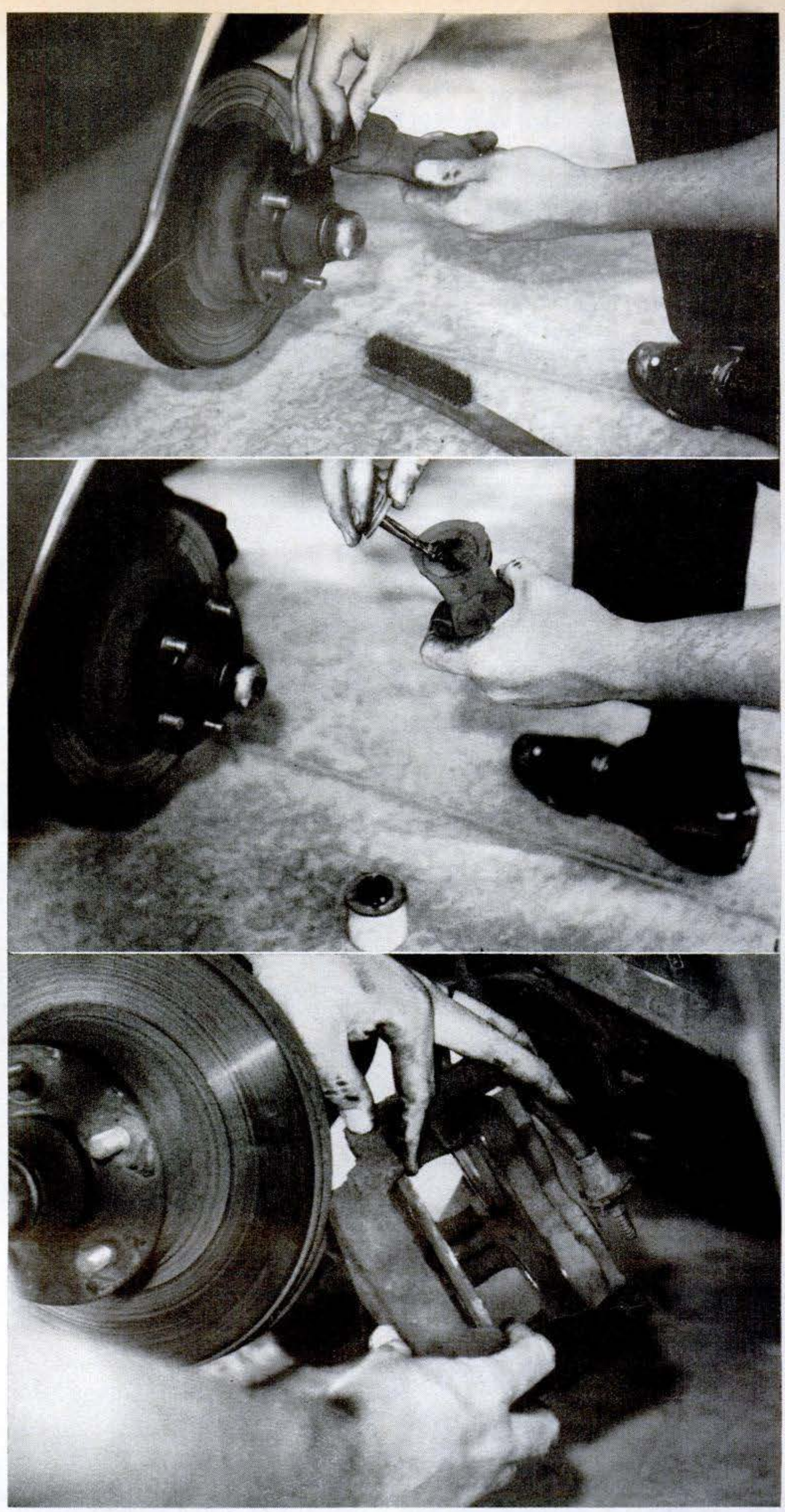
Removing a stubborn radiator hose can be a real chore. Make it easier by applying heat to an ordinary screwdriver and bending the shank about 1¼ inches from the tip. Now you've got the right tool for the job.



Slippery valve lifters won't let you get a firm grip? Slip a short piece of rubber hose over the lifter and hold it with a worm-type clamp. The hose provides plenty of grip to remove the slick lifter.



Checking the differential fluid? Use an ordinary pipe cleaner with a 90-degree bend near the end. When it's inserted in the filler hole, the exact fluid level in the housing can be accurately determined.



Brake squeal, on cars equipped with floating-caliper disk brakes, is often caused by a vibrating shoe assembly. To reduce the noise, remove the wheel and carefully slide the caliper away from the disk. Now remove the outboard shoe from the caliper. Top photo: Use emery paper or a wire brush to clean the dirt and rust from the steel back of the outboard shoe and from the caliper fingers. Middle photo: Apply a coat of heat-resistant adhesive to the shoe back and caliper fingers. Let the cement dry until the surface texture becomes a dull finish. Bottom photo: Carefully align the shoe in the caliper and press it firmly in place against the fingers so that the shoe sticks.

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[Continued from page 36]

and performance—not for price. And American Motors' V8 engines are equal to or superior to any power units built by the larger auto companies.

The Matador has the best combination of acceleration and economy in this group. That should come as no surprise. But handling? It did as well, or better, in our tests, than cars with better reputations in this area. As for brakes, Matador had the shortest stopping distance after warmup, with lower pedal pressure than when cold!

Points to note: Vent windows in front doors, plus cowl air intakes. Removable pouches in both front doors. Wipers are not articulated and leave a blind area on left side of windshield. Service accessibility is excellent. All elements requiring periodic maintenance are in clear sight and easy reach. No interior hood release.

Plymouth Satellite. It is almost as big as the Torino but has better space utilization. The interior feels freer, there is more room under the hood, and the trunk is vast and has a practical shape. The 318-cubic-inch V8 performed nearly as well as the larger-displacement engines in the other cars. Still, we would suggest that Chrysler make the 360 optional in the Satellite for customers who carry heavy loads or pull trailers.

We have often expressed criticism of Plymouth quality in the past, and it's a pleasure to report a noticeable improvement based on our test of this '72 Satellite. We had no electrical failures, mechanical problems, or hints of future trouble in any system. The workmanship was of a higher order, with better finish, trim, and body fits than on earlier models. Plymouth engineers told us last summer that their top priority was to improve quality, and now we have to believe them.

The Satellite lacks the ride comfort of the new Ford, still using leaf springs in the rear, while the other cars have all-coil suspension systems. Strangely, it also has some handling problems, and was unable to complete the lane change at higher speed than the Torino. Where the Ford understeers, the Plymouth oversteers. Some oversteer can be an advantage on C curves, but on an S bend it's a menace to control. In extreme situations, it tends to spin out rather than return to a straight path. On the other hand, the Satellite leads all intermediates in low-speed maneuverability.

Satellite's brakes proved to be on the good side of average in every respect. The only criticism that can be leveled at the Plymouth brake system is the proportioning, which allows premature rear-wheel locking and resultant loss of stability.

Points to note: Interior hood release is standard. Venting is by two cowl intakes with control knobs in center dashboard. Temperature and alternator gauges are standard (missing on other intermediates). Steering wheel looks like soft vinyl but is rock-hard plastic.

Conclusions:

Dunne: No question about it—I think the Matador represents the best value in intermediates offered by the domestic industry. Passenger comfort, roominess, and performance are major reasons for choosing the Matador.

Norbye: American Motors has a superior product in the Matador. It's a car designed for people to use, not for looking pretty on the showroom floor. And it's backed up by the most comprehensive auto guarantee now in existence. PS

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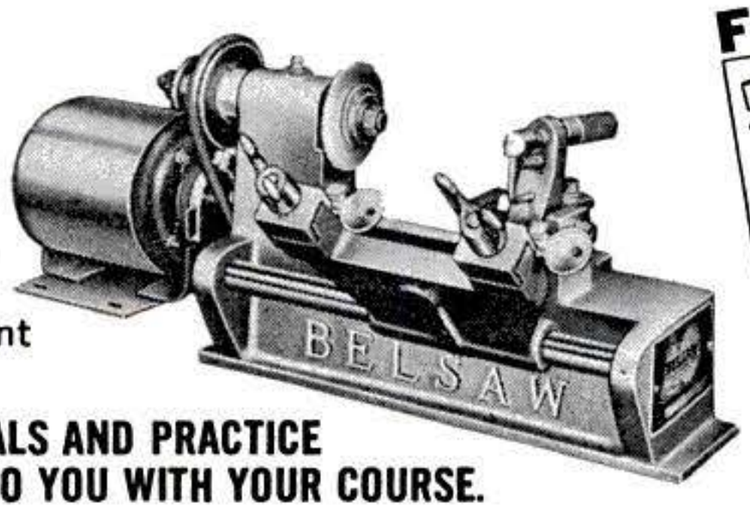

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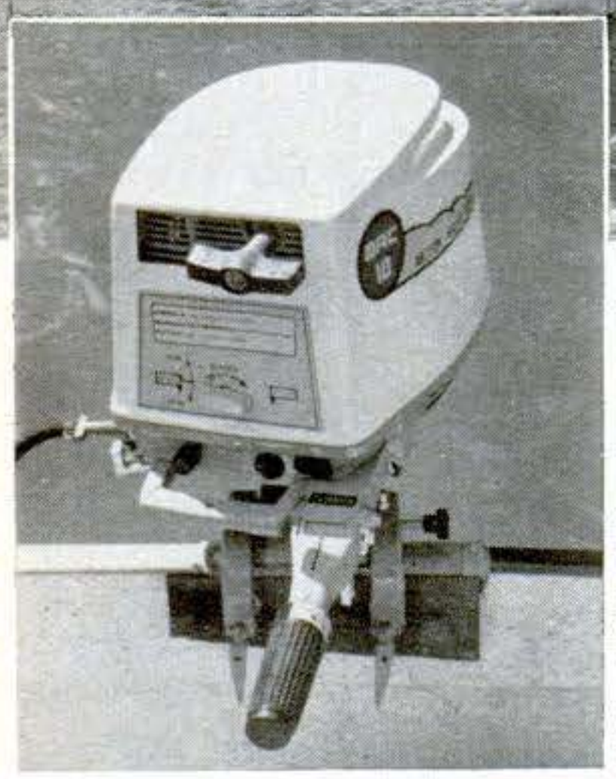
PERSONAL-USE REPORT

Now— A Wankel Outboard Can Power Your Boat

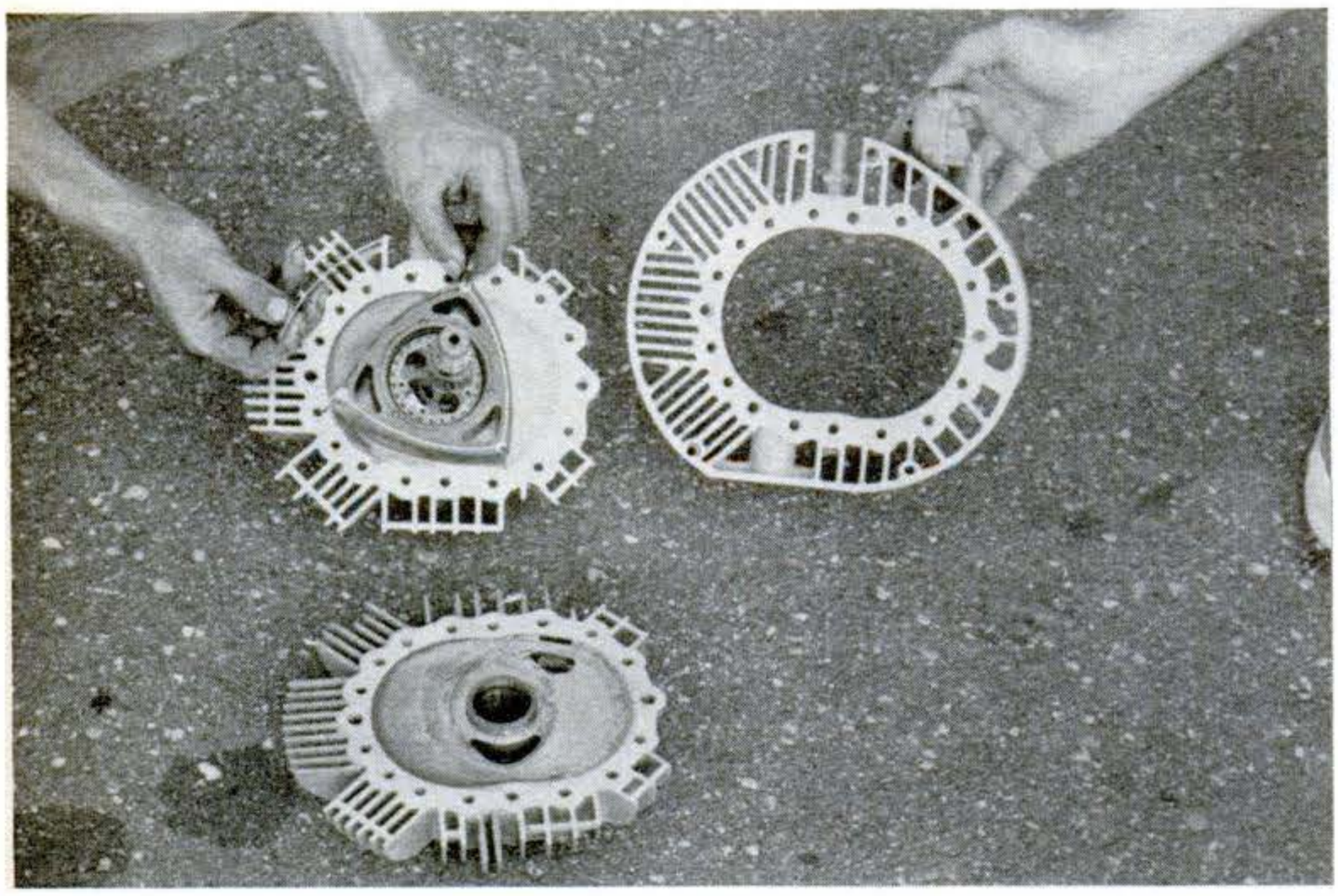
A Wankel for boatmen on sale in the U.S.? Right— you can order one today

By RAY HILL

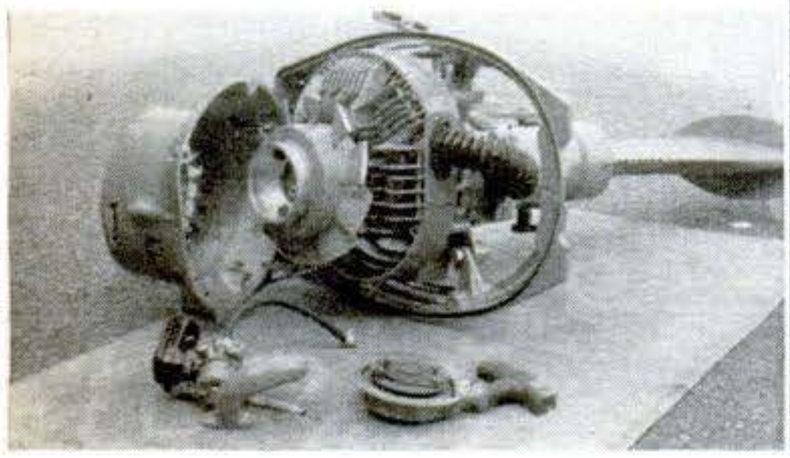


Engine accelerates smoothly and rapidly. Fuel mixture is 50 parts regular gasoline to one part outboard motor oil.

In performance, the Wankel outboard compared favorably with conventional piston outboards during the short time author used it. How the engine will hold up as the hours and years pile up is still an open question. Sachs engineers say all technical problems are solved, and that it'll last as long as a piston engine.



Cast-aluminum powerhead has three parts: sideplates, left, and rotor housing. The rotor's side seals and apex seals are made of the same cast iron used in reciprocating piston rings. Rotor housing's inside wall is coated with .020 special alloy, Elnisil, to prevent seal and rotor-housing wear. Gas-oil mixture passes through holes in rotor, cooling it and providing lubrication for rotor and bearings on each end of the rotor shaft. Displacement: 160cc per chamber. The powerhead is easily disassembled.



Air-cooled engine partially disassembled reveals fan (center), carburetor (left foreground), and recoil starter (right).

Engine started easily warm, even when purposely killed frequently. First or second pull restarted it every time.

Until you get up close and see WANKEL printed on each side of the cowling, the MAC 10 looks like any other outboard. Twist-grip throttle, choke, forward-neutral-reverse lever on the side, kill button, pull starter—the controls are conventional. That's on the outside. Inside, things get different fast. No pistons, rods, or wrist pins. Just one triangular rotor on a shaft that turns out eight horsepower at 4,800 rpm.

I borrowed one of the new Wankel outboards and ran it on a 10-foot dinghy for a couple of hours. It started easily and accelerated at about the same rate as any outboard.

The MAC 10 sells for $519, from Offshore Marine Co., 130 Market St., Annapolis, Md. 21401. Delivery time is 60 days. Service? All do-it-yourself —no authorized repair centers yet.

The Wankel powerhead is made by Sachs-Wankel in Germany. MAC, an outboard company in Milan, Italy, manufactures the marine components and assembles the units. PS

Sachs-Wankel Outboard Specs

Cooling	fan
Displacement	160cc per chamber
Compression ratio:	8:1
Horsepower	5 (DIN) at 3,000 rpm 8 (DIN) at 4,800 rpm
Maximum working speed	4,800 rpm
Ignition	Bosch flywheel magneto
Spark plug	Bosch W 190 M 11S
Contact-breaker gap:	.016 ± .002 in.
Carburetor	Bing throttle-valve carb 8/14
Air cleaner	wet (intake silencer)
Fuel feed	gravity
Exhaust silencer	oval
Starter	recoil
Engine lubrication	outboard motor oil and regular gas (1:50 proportion)
Weight	70 pounds

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New No-Wheels Train Gets a Lift from Magnets

[Continued from page 65]

each corner pair of magnets is an inductive sensor underslung from the car and also facing the rail. This small coil measures the precise distance to the steel rail above, and signals a fluctuating current to the electronic system that controls the thyristors regulating the DC to the lift magnets.

No ups and downs. When the gap closes, voltage to the magnets is reduced. There is then marginally less lift at that corner of the car, and an almost constant height above the sleepers is maintained.

The reverse occurs when the gap widens. Power to the four sets of magnets is individually corrected by the same feedback arrangement to provide all-independent suspension with inherent damping. No springs or shock absorbers are needed.

This control system is also the secret of the half-inch air gap. It prevents the magnets from clapping up against the rails as they would otherwise. Similar sensors control the guidance magnets. Here the coils face the vertical portion of the rails, and compensate for irregularities of these surfaces.

Since the vehicle has no wheels in contact with the rails to indicate distance traveled, an optical speedometer is used. Small squares of reflective paper are spaced evenly along one side of the aluminum reactor plate. A photocell detects light beams on the line of squares and converts the flashes into electric pulses of a frequency directly proportional to the speed. The pulses operate an electronic indicator.

What really impressed me about magnetic levitation was the ease with which the floating car can be moved. At the end of my ride, the engineers returned it to its terminal shed, where the high-voltage rails stop short of a working pit. After plugging a flexible electric cable into the side of the vehicle to energize the magnets, one man pushed it home with a gentle shove. I found I could pull the five tons along with just my fingertips.

Though still in its infancy, magnetic levitation looks better than its rivals in several areas. To lift the same weight with magnets, MBB claims, requires only one-seventh the power a hovertrain needs to fill an air cushion. That's because the air losses of an ACV are far greater than the heat losses of a magnet. In fact, levitation accounts for only five percent of the power consumption, the rest being for propulsion.

Advantages of speed and silence over a wheeled railcar are clear-cut. But there's also safety. With magnetic suspension the car can't derail. The magnets lying beneath the track would hold the car down in a crash. For braking, the linear motor, switched to reverse, beats wheels that depend on friction. And in an emergency, lift magnets can be cut so the car skids on its parking blocks with the reversed motor providing extra drag. Track maintenance should be slight, for there is no mechanical loading. Moderate icing of the track should not affect performance—there is no direct contact with the rails.

Rosy future. There are bright possibilities. A sophisticated adaptation of the optical speedometer principle could automatically control speed and braking on runs. Spacing of reflective squares in a separate line on the reaction plate would be varied like a punched tape to program motor power for long straights, curves, bridges, grades, deceleration, and stops. Another line of squares on curved sections could boost power to the outside guidance magnets to counter centrifugal force.

For a big jump ahead in levitation there are superconductive magnets on the horizon. Ignoring Ohm's law, these exciting miracle magnets have no electrical resistance, and thus consume virtually no power. Coils are wound in filaments or ribbons of exotic metals such as niobium-titanium composites, which have extremely low losses when cooled by liquid helium to around four degrees Kelvin (about four degrees above absolute zero).

The only power required is for refrigeration, and for a given strength, the coreless superconducting unit is far smaller and lighter than a corresponding iron-core magnet.

What's the next step? MBB is planning a six-mile test track with curves and gradients, running a car capable of 240 mph. For this it is now developing more powerful magnets and motors, collector shoes capable of giving reliable current pickup at this speed, and a more advanced control system.

At the same time, MBB is preparing a study for the government of a long-distance, track-guided transport. One possible outcome is a 480-mile track from Munich to Hamburg.

A 240-mph train could cover that distance in two hours. Carrying loaded trucks from the heart of Bavaria to Germany's major port, it would slice transport times, reduce road congestion, and compete easily with air freight on point-to-point times, and certainly on costs. PS

It's a plastic tube with liquid inside . . .

Bend it, and at once it glows brightly . . .

. . . to make a three-hour emergency light.

PERSONAL-USE REPORT

For Emergencies: A Chemical Light Wand

If fireflies do it, why can't we? That's what the folks at Coolite Corp. (485 Madison Ave., N.Y. 10022) asked themselves—and answered by developing the Coolite. It's an emergency light that works by that firefly phenomenon, "chemiluminescence"—chemical light. Inside the plastic tube shown above is a thin glass tube. Each contains a liquid chemical. Snap the glass tube (by bending the outer tube) and the chemicals mix—and glow brightly for three or more hours. Great for home, road, or campsite. About a dollar.—*E. H. Ortner*

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The Detergent Mess—What to Tell Your Wife

[Continued from page 16]

its equivalent in grams per recommended use levels. Check this "use-level" label to calculate the relative cleaning power of your detergent in terms of cost and quantity.

To beef up the cleaning power of low-phosphate detergents, some companies added the old standby, washing soda (sodium carbonate) plus some silicates. This mixture softened the water by combining with minerals in hard water to form an insoluble residue, as in the pre-detergent era. But in modern automatic washers, water is removed from laundry during the spin cycle by centrifugal force, which presses the wash water through the clothes, and the fabric, acting as a filter, traps the curds. As a result, the laundry comes out harsh, stiff, and gray.

A more serious drawback . . . These nonphosphate additives are caustic (alkaline). If inhaled or swallowed when dry, they can destroy the tissues of the nose and throat; if handled when wet they erode the skin of the hands. One tragic example: the death of a 15-month-old girl who swallowed a mouthful of dry detergent containing caustic soda. The danger is widespread. In 1969, some 3,900 children were reported to have eaten comparatively harmless phosphate detergents. If these cleaning products had contained caustics . . .

Today all detergents containing caustics must carry a warning label that varies in severity according to the health hazard (see table).

It has also been noted that highly alkaline detergents may shorten the life of some fibers, notably wool and, to a lesser extent, cotton. Still, used with ordinary care, such "low-phosphate," "nonphosphate" or "nonpolluting" detergents have their uses.

Neil Johansen, Senior Chemist at Limnetics, Inc., a Milwaukee consulting firm, gave us this advice: "If you have a septic field that drains into a small lake, don't use phosphates. But if you have really hard water and can't afford a commercial water softener, you pretty much must use phosphates." It should be added that if you have soft water and lightly-soiled clothes, low-phosphate caustic detergents will probably do the job—and most Americans have soft water. But the soil and dirt in grimy laundry can harden even the softest wash water, in which case phosphates would be more effective.

Enter the enzymes. Meanwhile, back at the lab, detergent companies were busy creating a new laundry product —enzyme soaks, designed to remove some stains that resist detergent action. The enzymes in laundry products (amylase, lipase, and protease) are derived from the digestive juices of the bacteria *Bacillus subtilis*. The enzymes are catalysts, substances that speed up chemical reactions. They accelerate the breakdown of complex molecules of carbohydrates, fats, and proteins into simpler molecules, which can then be removed by detergents.

The types of stains on which enzymes work best are grass, blood, diaper soil, eggs, milk, baby foods, gravy, chocolate, and some vegetables and fruits. They have little effect on inorganic stains such as rust, ink, or graphite, fat-based stains such as cooking oils, or on highly pigmented stains such as mustard, or on dyes that have bled from one garment to another.

It has long been known that there is a health hazard in enzyme manufacture; enzyme dust had corroded workers' skin and sensitized their lungs causing asthma-like symptoms. The detergent makers claim that the enzyme concentrations in their products are so small as to be harmless. Although there have been no reports of allergic reactions among housewives, the long-term effects of these products are not known.

Must it be snowy white? A recent study by Rene Dubos, Professor Emeritus at the Rockefeller Institute, suggests that the laundry enzymes are not pure but contain many other bacterial substances. These, says Dr. Dubos, might possibly be poisonous, might support infections, and might damage the blood. Is a whiter wash worth all this risk?

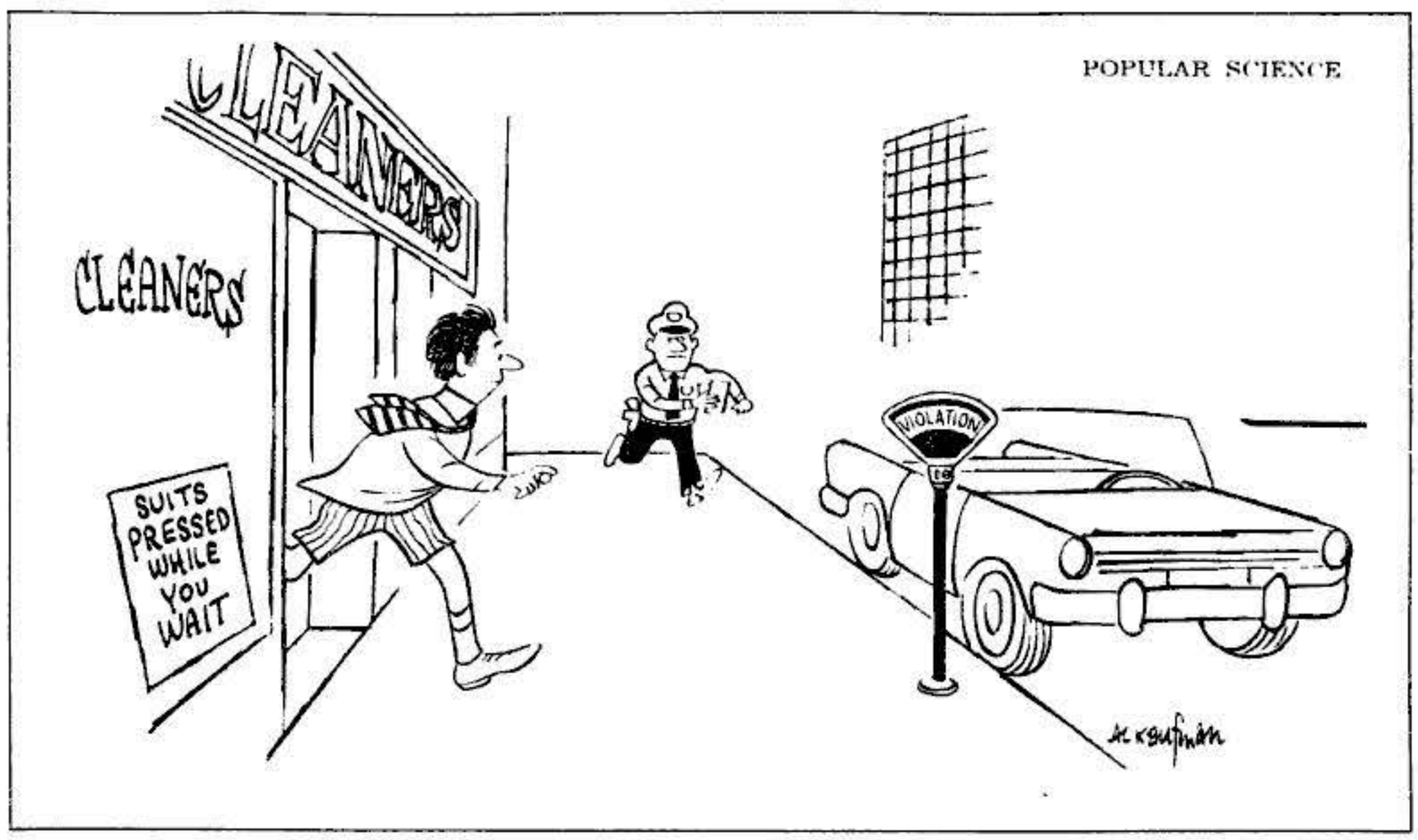
Probably not, as enzyme soaks don't seem to work too well anyhow. Enzymes work slowly; clothing must be saturated for at least an hour or more. Detergent-enzyme combinations in a washing machine do not allow enough soaking time for the enzymes to attack the stains.

Recently, however, the Federal Food and Drug Administration released a special study on enzymes that apparently lifted some of the onus on enzyme laundry products.

The study was conducted by the National Academy of Sciences-National Research Council (a nongovernment group of scientists). The study found that "the average enzyme detergent laundry product in normal use by consumers hasn't produced more primary irritation of the skin than have similar products that contain no enzymes." Still, both the FDA and the Federal Trade Commission expect to review more evidence before making any final decision on whether or not regulatory action is needed.

With this background, what's a mother to do? Cutting back on phosphates might result in less thorough cleaning, but whether or not everything we touch must be squeaky-clean is debatable. Even the experts disagree on how importantly phosphates contribute to eutrophication, and even on what areas we should worry about. But two of the "big-three" detergent manufacturers, Colgate-Palmolive and Lever Brothers, recently asked the federal government to set "reasonable limits" on phosphate content.

Proctor & Gamble varies its phosphate content regionally—high in New York City, low in Chicago. A recent test by a consumer organization showed that with water of average hardness for the U.S., phosphate-free detergents gave acceptable results. But the phosphate controversy promises to bubble on for some time to come. PS



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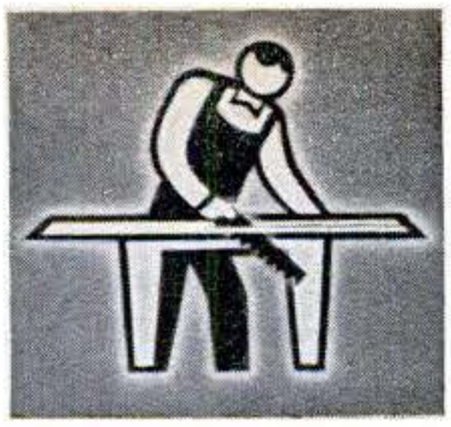


SHOP TALK

By ROBERT P. STEVENSON

Passing parade of interesting new products and catalogs

Now you can pick a tobacco pipe to match your colored shirts. Venturi, Inc., Burlingame, Calif., offers pipes in eight styles in hand-painted stripes and a variety of solid colors . . . A handsome line of decorative hardware in brass, porcelain, and wood is available from J. C. DeJong & Co., 120-15 91st Ave., Richmond Hill, N.Y. 11418. A 56-page catalog will cost you a dollar . . . Send a self-addressed envelope to Dupli-Color Products, 1601 Nicholas Blvd., Elk Grove Village, Ill. 60007, for a free booklet telling how to do your own professional-quality touch-up painting on your car . . . A new slide chart enables you to figure out the cost of lumber fast. One side automatically converts the board-foot cost of dimension lumber to the linear-foot cost. The other side gives the cost per piece. The 8½"-by-11" Lumber Pricer costs $3.95 from Alcott Calculator Co., 222 Weber St., Orlando, Fla. 32803 . . . The Disston Division, H. K. Porter Co., Porter Bldg, Pittsburgh 15219, offers a free handsaw guide booklet . . . Maybe you haven't noticed, but the bib overalls that a lot of us older hands used to wear have come back. The Sears catalog stocks them now—for the style-conscious younger set . . . Did you notice the tempting Christmas tool packages all of the tool companies offered this season? How could any female shopper with a what-to-choose problem pass up Stanley's home screwdriver set?

Do-it-yourself films show how to improve your home

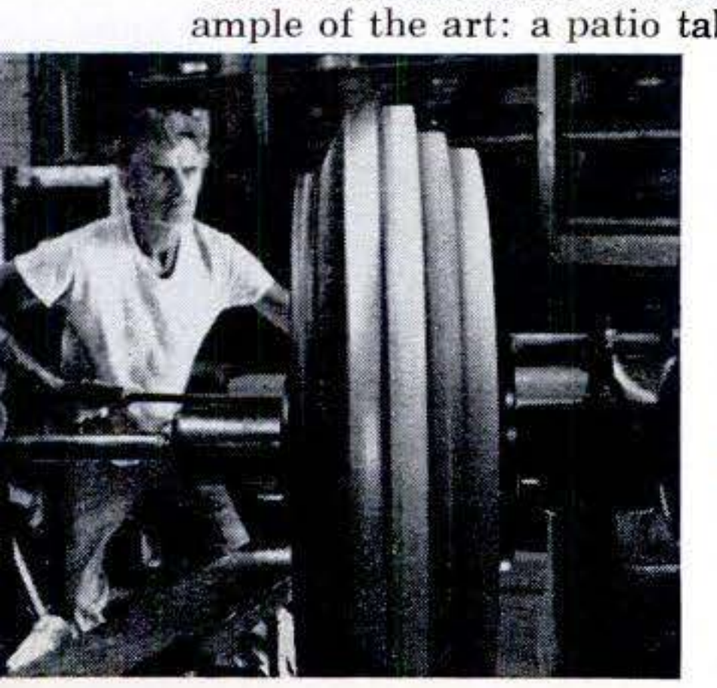
When you want to undertake a home-improvement job, wouldn't it be great to see a movie on how you go about it? That's no longer a dream. The National Lumber & Building Material Dealers Association is promoting just such a visual information program. The program may not have reached your region yet, but how can it fail to spread? Participating dealers advertise that films on a variety of subjects can be viewed at their stores—just come in and ask for a viewing. You also get literature describing the job, and guidance (natch!) on what materials to buy. Films now available show such jobs as paneling a room, installing ceiling and floor tile, laying asphalt shingles, and painting the house. This list, of course, is just a start.

Lumber supermarkets are a great idea—and growing

When buying lumber, lots of us like to wander out among the stacks and look over the goods before making a choice. In old-style lumber yards it hasn't always been easy. Reports indicate that the situation is improving in some areas. Lumber supermarkets have been a success wherever established. You walk in and wander where you will, examining at first hand each of the many species and forms of wood products available. A Saturday morning spent that way can be a real ball. Some markets even provide shopping carts for toting along what you need—or can't resist. Others have free trailers for hauling home what you buy.

Metal spinning in big way results in a prize winner

Metal spinning is an interesting craft procedure that POPULAR SCIENCE has described from time to time. Recently, a good friend of mine at the Kaiser Aluminum & Chemical Corp. sent me details about a fine example of the art: a patio table that Gary Neville, a California designer and architect, created. The Pasadena Art Museum displayed it as an example of a "seldom-found meld of modern materials and technology worked into a functioning piece of art, all sensitively executed." For his work, Neville shared a $1,500 design award. Neville had the help of Robert Handrick, president of Western Metal Spinning, in bringing his design ideas into shape. In the photo, a workman is seen using a lance-like tool to spin the aluminum base for the table. The finished table consists of the circular aluminum base topped off with a chromed-steel rim. The rim holds a disk of heavy plate glass.



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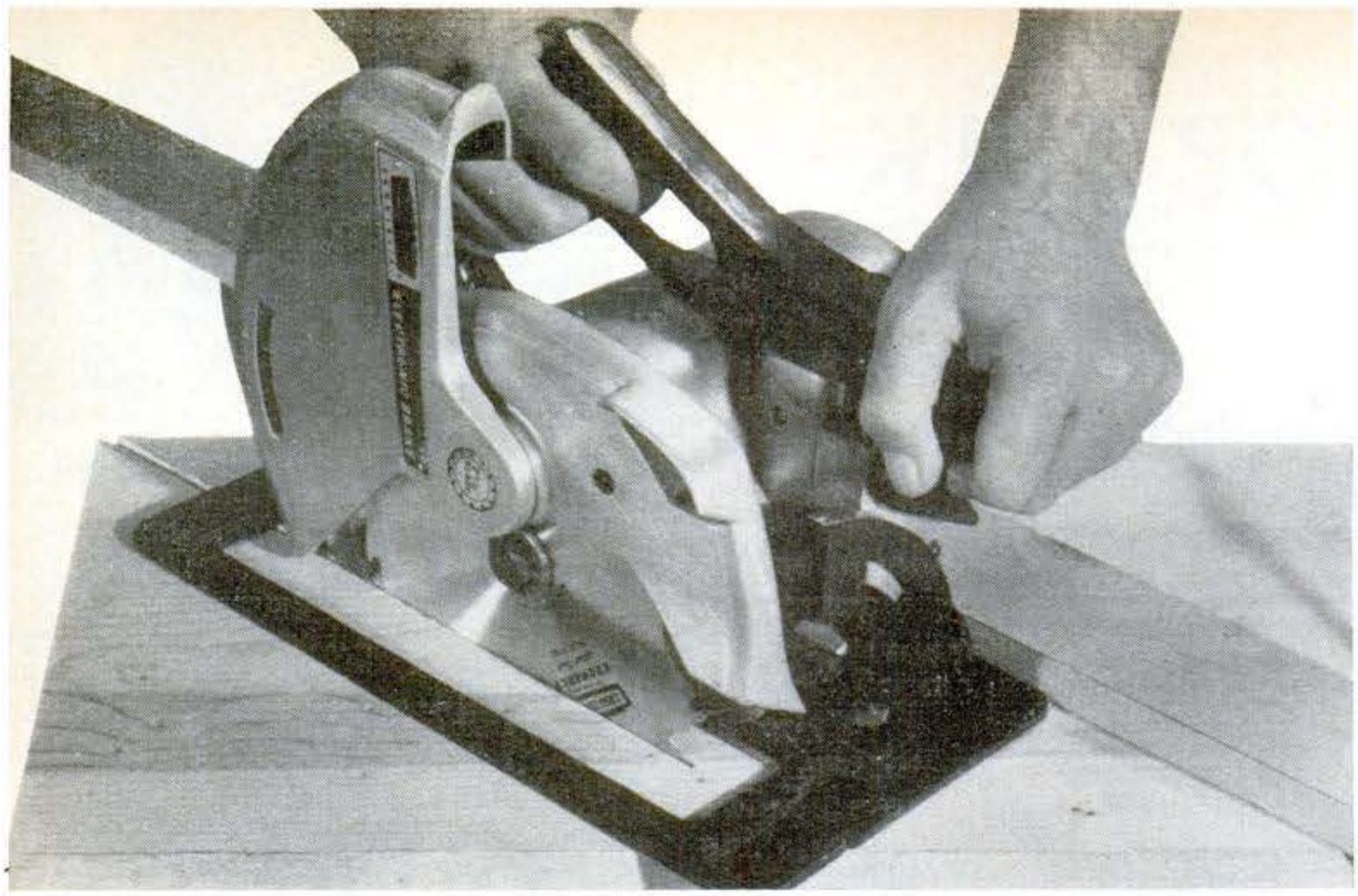
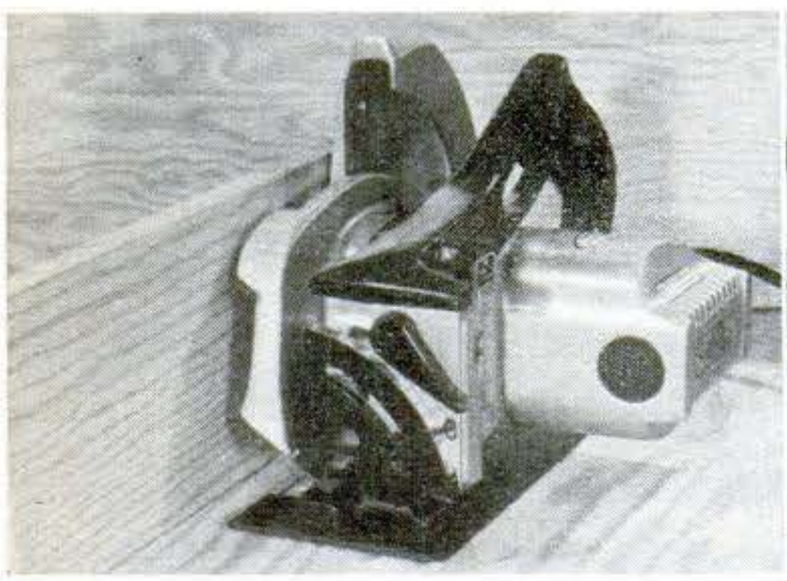
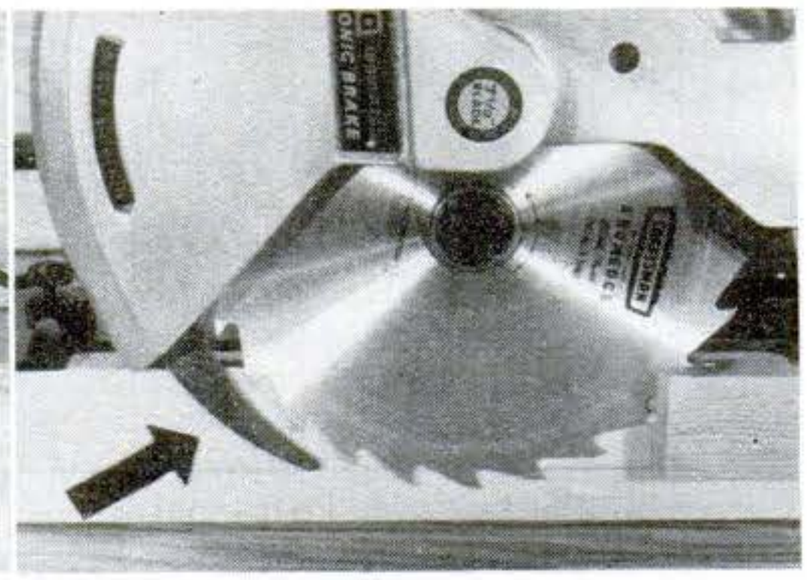


Plenty of power, convenience features, good balance, and man-sized two-hand grip make the Sears saw equally at home on construction sites or in the home workshop.



Saw works close to obstructions if you remove outer section of two-piece baseplate. Housing is nonglare brushed aluminum.



Riving knife—shown in end view—keeps the kerf open and prevents binding, even in green wood. Remove it for plunge cuts.

PERSONAL-USE REPORT

A Circular Saw with All the Features

Compose a list of the features a top-notch circular saw should have and you'd pretty much draw the concept of this new 7½-inch Craftsman contractor saw. The "contractor" designation puts it in the high-power (12 amps) class for big pro jobs, but it's ideally suited to the home craftsman involved in building and remodeling, deck construction, fence erection, and the like.

Double insulation, a riving knife, and an electronic brake contribute to user safety. The brake is startling. Release the trigger and the saw stops —just like that. There was no point in putting a stopwatch on the thing; my reactions weren't fast enough.

The riving knife does for the portable saw what a splitter can do for a table saw. It keeps the kerf open so the work can't bind the blade. It does get in the way on some jobs—plunge cuts and such—but it's easy to remove when necessary.

Convenience features include an arbor lock and a two-piece base. The lock is a button-activated plunger that engages the shaft to facilitate blade changing. The two-piece base lets you work close to obstructions; just remove the outboard section.

Maximum depth of cut at 90 degrees is 2⅝ inches. This drops to 2 3/16 at 45 degrees. A vertical action rather than pivot controls depth-of-cut adjustments. You'll have a natural tendency to make adjustments by moving the tool and keeping the baseplate still. But it's much easier to adjust the baseplate to the tool. The bevel block and quadrant seemed a little light to me, but they held up fine through many adjustments and much cutting.

This new saw turns a 7½-inch blade at 5,500 rpm. It puts out over two horsepower, and I couldn't stall it. It's a lot of saw. The price is $79.50.—*R. J. De Cristoforo*

Wild New World of Drones

[Continued from page 71]

JATO rockets or air-launched from Lockheed C-130 Hercules.

In one embarrassing situation, 147 Firebee returning from a missio was mistaken for a MIG-21 and sho down by four Navy Phantom F-4s a signed to protect the C-130 comman ship directing the Firebee's flight.

An authoritative description what the new family of RPVs migh do comes from a symposium of e perts under the management of Me vin Tanchel, Air Force System Command, and William B. Graha of the Rand Corp.

For an air-to-air superiority figh er, they felt the best concept was three-stage system. A mother shi carrying two RPVs would use rada to locate enemy fighters at about 6 miles distance. Air launched one a time, each RPV would carry tw rockets, possibly a gun or cannon, ar in the future a laser weapon.

For close air support, the sym posium's report states, RPVs could b recoverable or expendable. The r coverable vehicle could be groun launched carrying 2,200-pound loa a radius of 250 miles. The load cou be terminal-guided bombs, clustere bombs, or guns. Maximum weigh would be 7,500 for an external-bom load version and 8,400 for an interna bomb-bay version. Costs at take would be $150,000 to $175,000 eac

When will all this come about? F public consumption, experts feel th while most of the technology is ava able now "off the shelf," such a sy tem is about 10 years away. But fro talking to various experts, I got t feeling this is a maximum time fram Lots of RPV activity is going on no Some designs I saw are well a vanced in prototype design and, I w told unofficially, could be in produ tion in less than a year.

One of the great mysteries is wh we have not heard more about targ drones and RPVs from the Sovie and Chinese. It is obvious that the requirements are similar to ou They're also well aware of our effor in this direction. We may be in f some rude surprises one of these day It's hard to forget the first Sputni

At this time, little attention h been given to nonmilitary uses b cause of the need for large-sca funding. When I mentioned possib applications for crop dusters, pipeli patrols, police traffic reporting, a even air freight delivery to remo Arctic areas, no one said these we impossible or impractical.

Who knows, some day you m even get a ticket for speeding issu by an overhead RPV on patrol.

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Heat Runs Amazing Rubber-Band Motor

[Continued from page 96]

not bind. It is important that the crankshaft move freely.

Eighteen nails must be driven through the rubber tensioner from the underside to hold the rubber-band ends. Use a protractor to mark out 20-degree divisions on the underside of the disk. Drive a ½″ brad through the disk on each mark. Keep the brads about ⅛″ from the edge.

Use a small rectangle of aluminum about ¼″ thick to make the canopy hub. Drill a ⅛″ hole through it so it will slip on the top end of the crankshaft. Drill and tap a connecting hole from the side for a 4-40 bolt that will lock it in place on the crankshaft. Drill other holes for bolts to attach the hub to the canopy.

If metal drilling and tapping are beyond you, go to a local machine shop. Or perhaps you can find help in a high-school shop.

The canopy frame. Lay it out on a sheet of corrugated cardboard. This makes the canopy light in weight and sufficiently rigid to be self-supporting. Cut out the canopy.

Make holes for the bolts that hold the canopy hub in place. Locate the holes to position the hub so that the center of the canopy frame will come exactly over the center of the *bottom* of the crankshaft. If your crankshaft's throw is off from the ½″ shown in the drawing, shift the canopy frame on the hub so the canopy runs true and on center.

Cover one half of the canopy frame with aluminum foil. Bend it over the edge, and attach underneath with transparent tape. This will form the shadow portion of the canopy. The bolt locking the canopy hub to the crankshaft will be accessible through the uncovered part of the canopy.

Pass a knitting needle through the center of the canopy frame as a balancing axle. Add small weights to the edges as necessary, so the weight balances when the canopy is turned edgewise (see photo). Nails pushed into the corrugations make good balancing weights.

Now for the rubber bands. You can get them at any store that sells stationery supplies. I used size-32 natural-rubber bands by B. F. Goodrich. Any 3″ rubber bands may be used as long as they are all identical. Natural-rubber bands, light tan in color, are far superior to synthetic-rubber bands, recognized by their bright colors.

The forces in the field of the Joule-effect engine tend to balance one another. The more perfectly they are in balance, the smoother and faster the engine will run. Hook a rubber band over one nail in the rubber tensioner, hooking the other end over one nail on the edge of the engine frame. Hook the next rubber band in on the opposite side from the first.

Continue back and forth, adding rubber bands until all 54 are in place. From each nail on the rubber tensioner, three rubber bands will stretch out to three adjacent nails along the edge of the engine frame.

Delicate balance. When the rubber bands are all in, the crank will probably move to one position from which it is difficult to move it. This indicates a slight lack of balance in the field of rubber bands.

Note which way the throw of the crank is pointing. Take off the band opposite to where the crank points. Tie a knot in the band, and put it back on. The knot shortens the band and increases its tension.

If the crank points in a new direction, repeat the process. When the bands are in perfect balance, the crank will stay at rest in any position you turn it to. You may have to knot as many as half the rubber bands.

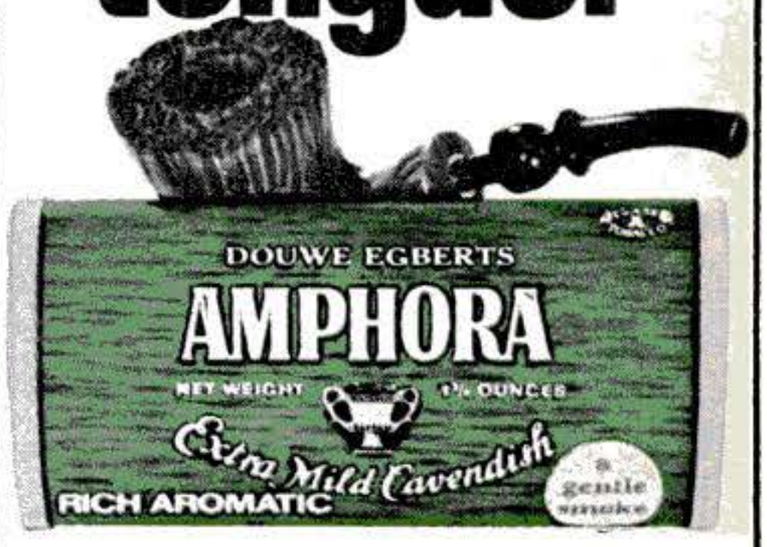
Next, put the canopy on the crankshaft. Position the canopy so that the throw of the crankshaft is parallel to the straight edge of the aluminum foil that covers half of the canopy. With the field of rubber bands balanced and the weight of the canopy in balance, the canopy-crankshaft assembly should remain in any position you put it, regardless of how the engine is tipped.

Now expose the engine. A source of direct radiant energy, such as a radiant heater or heat lamp, will start it in motion. Radiant energy passing through the canopy openings heats the exposed rubber bands. As they contract, they pull the crank toward the exposed side.

The covered area of the canopy reflects part of the radiant energy, which keeps the bands under it relatively cool. When the crank rotates, the canopy moves with it, so the rubber bands are subjected to alternate heating and cooling, which keeps the engine running smoothly and steadily.

You will notice that the field of rubber bands will develop a "set" if the engine is stationary for a period of time. This is because the rubber tensioner is held off-center by the crankshaft, and the rubber bands are stretched unequal amounts. It normally requires that only one or two additional rubber bands be knotted to restore the field of rubber to a balanced condition. As the rubber bands age, the engine will lose speed and power. PS

A new taste to remember, but not on the tip of your tongue.



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RV Standards on the Way

[Continued from page 82]

ers is much less than most RV owners believe. DOT also found that although most states charge license fees based on camper GVW, there was no relation between the actual GVW and the licensing GVW in many instances.

Manufacturers who have been approached by the federal men have been completely cooperative in helping to provide guidelines for the vehicles, Brooks says. In fact, he adds, manufacturers themselves are initiating safety programs on their own. One example is a new organization, The Trailer Hitch Manufacturers Assn., which has been conducting an extensive testing program to improve their products. This is being financed by the member companies.

As the survey closes this month, DOT will start to send out letters to all 5,000 of us who participated in the project. We will be told the correct facts on loading our campers. The condition of our campers and towing vehicles will also be detailed in the letters.

Those of you who were not as lucky as I was and did not have an opportunity to take part in the survey have a tougher job in figuring out how to use your camper in a safe way.

The federal officials offer some sound advice on how to insure that you pick out a camper that will do the job you want in safety:

- Tell the dealer to supply you with the empty weight of the vehicle.
- Ask for the "as-delivered" weight of the unit.
- Get the GVW so that you know how much of a load you can put in the vehicle, including passengers.
- Have the dealer show you how to weigh your vehicle. It should be weighed with all tanks full.
- Find out what the load capacity of the vehicle is, axle by axle—and also what the proper load on the tongue should be. Experts say that 15 percent of gross trailer weight should be on the tongue. More than that will push down the rear tires of your towing vehicle. Much less, and the rear of the towing vehicle may be lifted dangerously.
- Last, get adequate tires for your vehicle and keep them inflated to the proper pressure.

When the new standards come into being, much of this work will be done for you by the manufacturers. Until then, you'll have to make your own safety checks. It's worth doing. The stakes are high—not only in terms of money, but to insure a trouble- and accident-free vacation for you and your family. PS

Erect This "Kit" Garage

[Continued from page 97]

How much time? Figure a min mum of two weeks' building time on you take delivery. Working with on hand tools (the local power compar reneged on its offer to run in an ear line), an unskilled friend and I g the structure framed in eight days. took three more weekends to app Texture 1-11 siding and self-seal a phalt shingles, and to install awni windows and overhead door. Sure, put in some nonunion, 10-hour day but such a structure grows fast.

If starting from scratch, you'll ne two saws (crosscut and rip), hamme plane, brace and bits, chisel, wrenc carpenter's square, level, 25′ tape.

How much? I bought Grossman smallest garage package—the 12′-b 22′ Monmouth—for just over $60 plus a $25 delivery charge and loc tax. In other parts of the countr where lumber is cheaper, chains ma offer an equivalent package for les Even if you have the concrete sl poured for you, your costs won't clim much over $1,000 for a garage of th size—and that 22′ length is ample f workshop space at the rear. If y want something larger, your lumb chain probably offers it at a propo tionately higher price.

Once you've completed erectio of course, you're on your own. N weatherstrip, caulk, or finishing m terials are usually supplied. (I cho a semitransparent penetrating sta for the siding, a durable deck enam for the trim.)

If you want to winterize or finish the interior, that's at your own e pense. The combination I chose, shown in the last photo, is best for a year "working walls." The John Manville 2¾″-thick foil-faced ba insulation is anchored to the studs stapling flanges that create an ide recess for inserting heavy-duty hoo through ¼″ Peg-Board. (I appli the board with Masonite's panel a hesive, to minimize nailing.) If s very glitter through the perforatio is objectionable to you, use a kra paper-faced batt.

Between the 2-by-6 rafters, I s pled J-M 6½″ Super-Thik Spinsu tion. Unlike the thinner stuff (whi comes in long rolls from which y uncoil and cut exact lengths), Sup Thik is packaged in 4′ batts, for eas overhead handling.

Heavy-duty Peg-Board glued 16-o.c. studs, is hefty enough for most anything you'd want to ha from it—including your lawn mow and snowthrower. Consider this terior finish a bonus you can afford give yourself because of what you saved by going the "kit" route.

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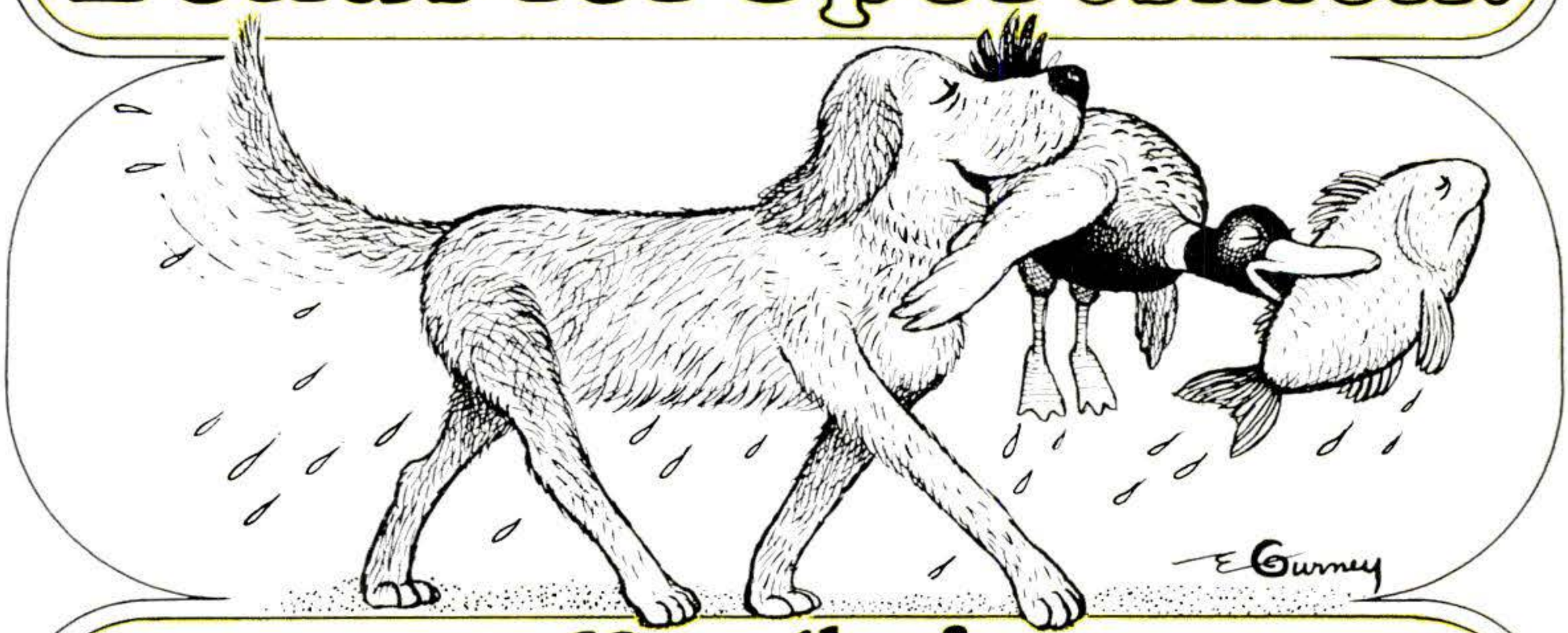

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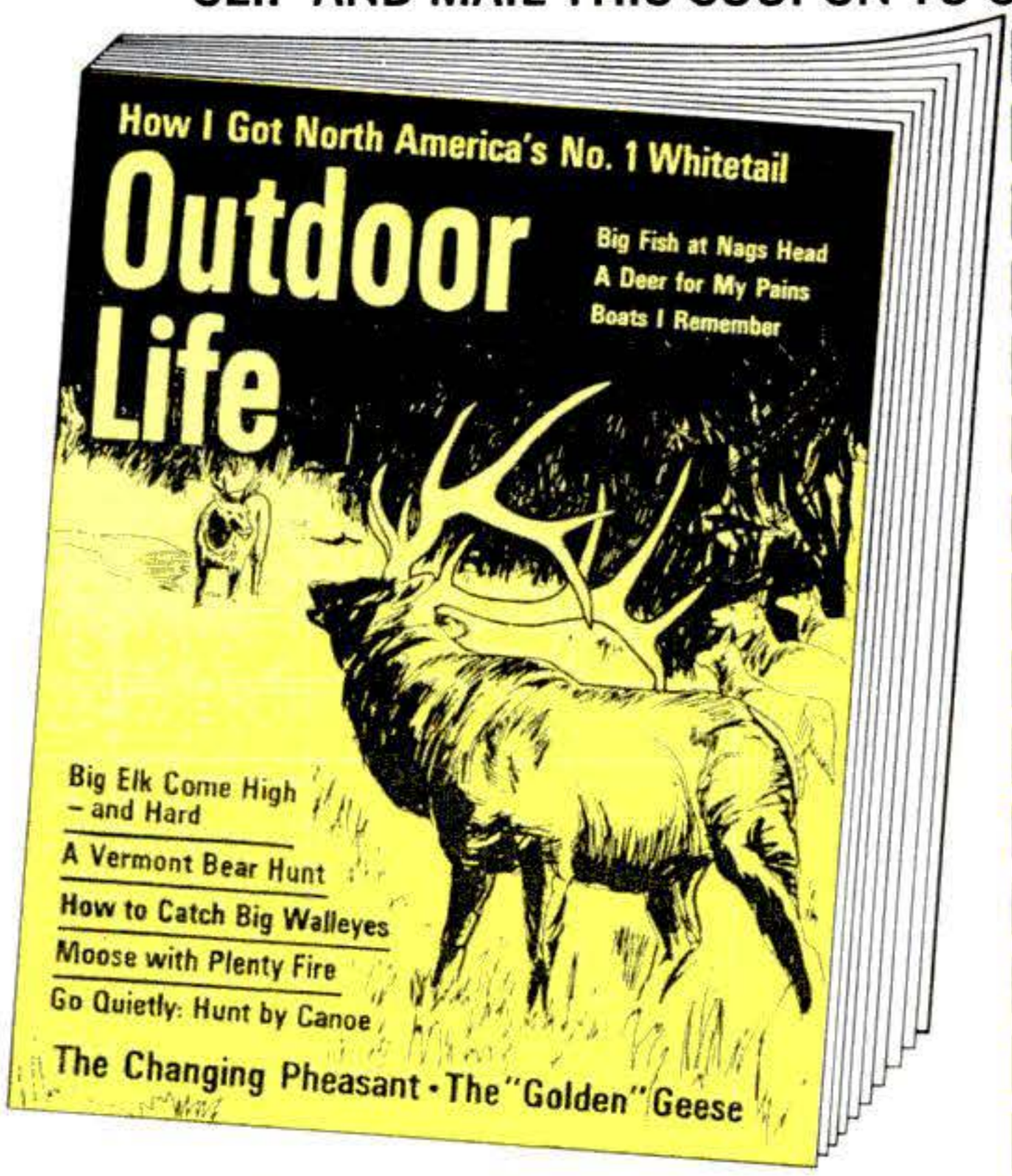

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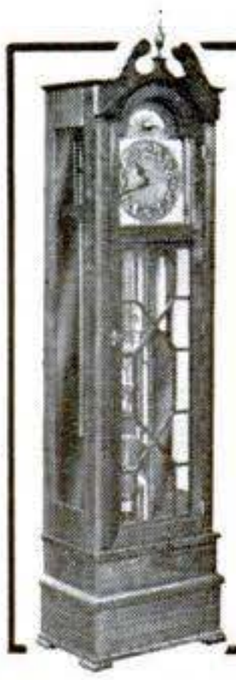

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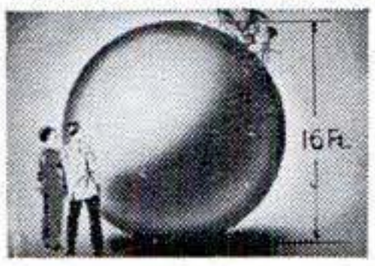

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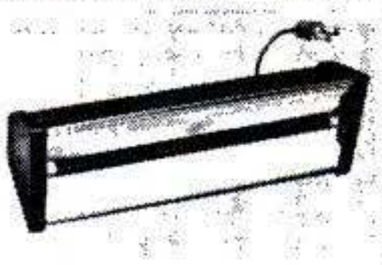

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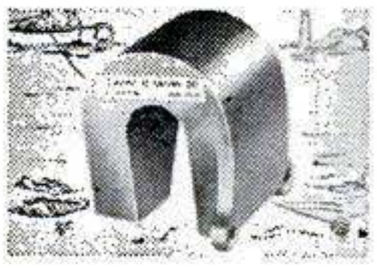

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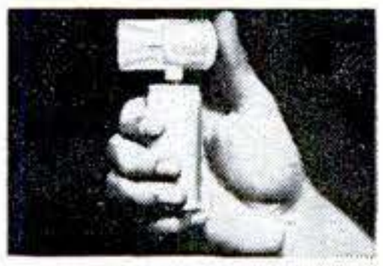

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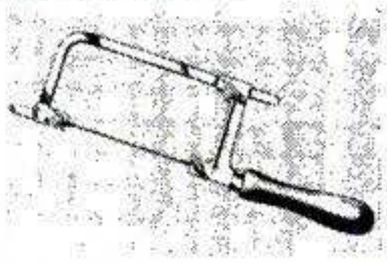

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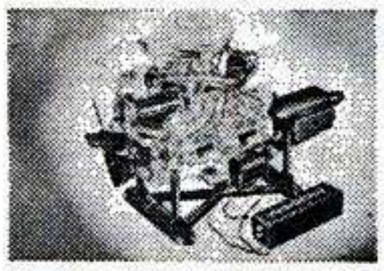

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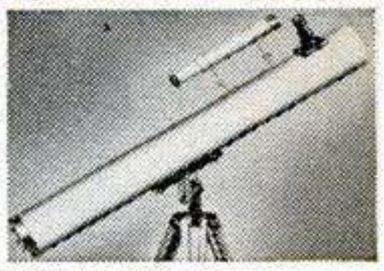

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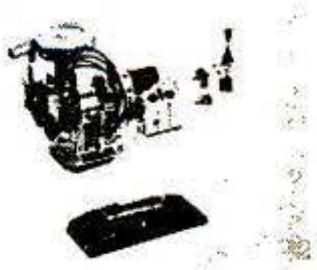

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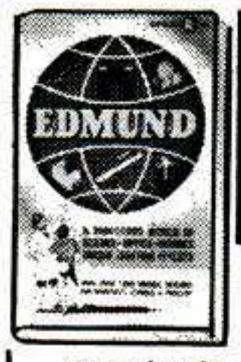

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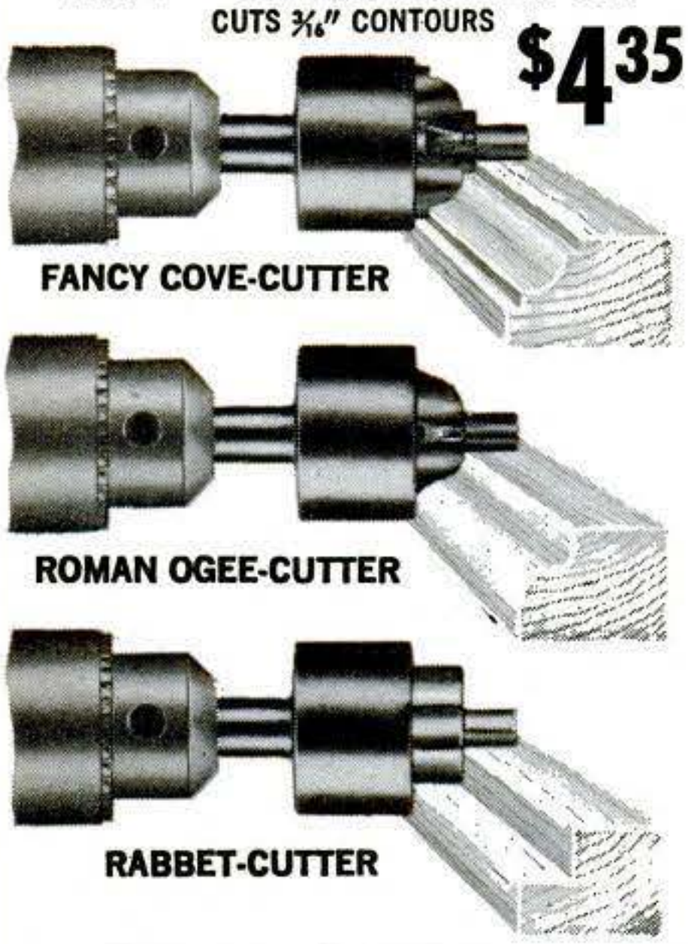

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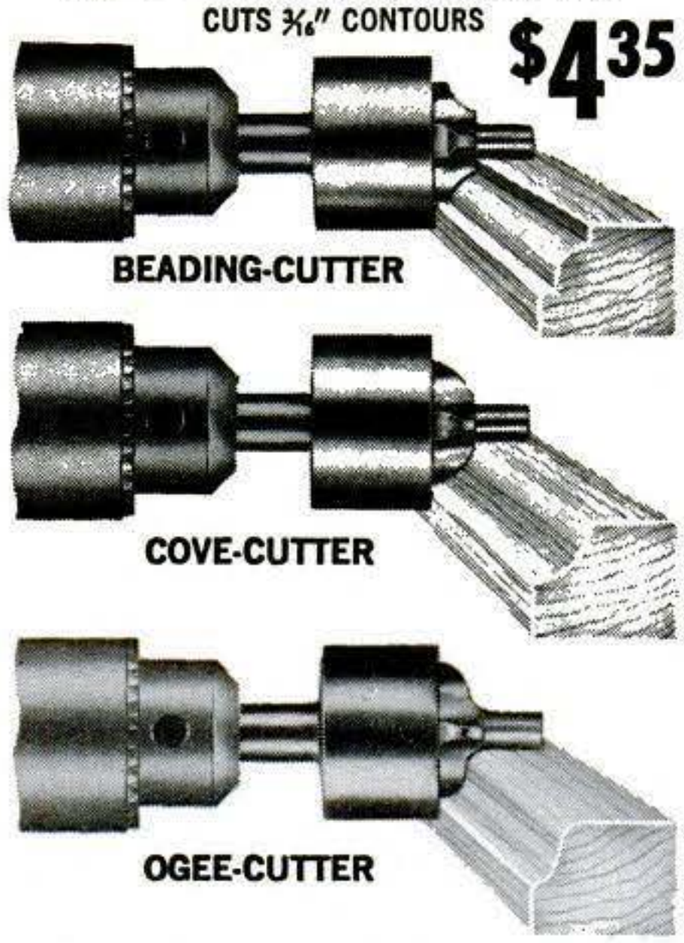

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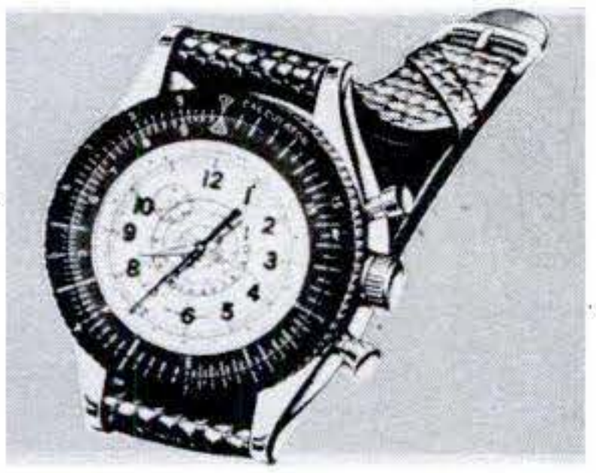

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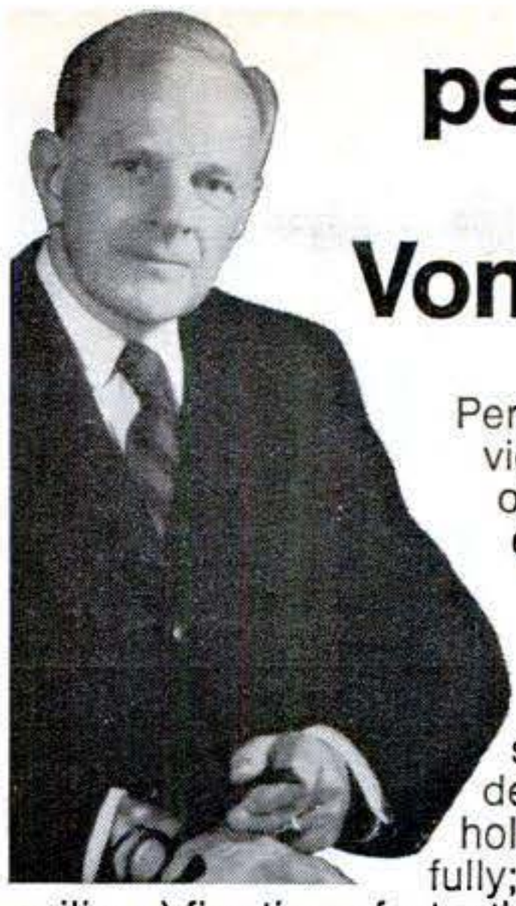

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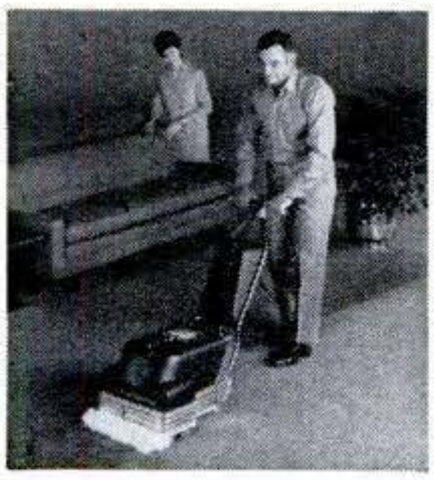

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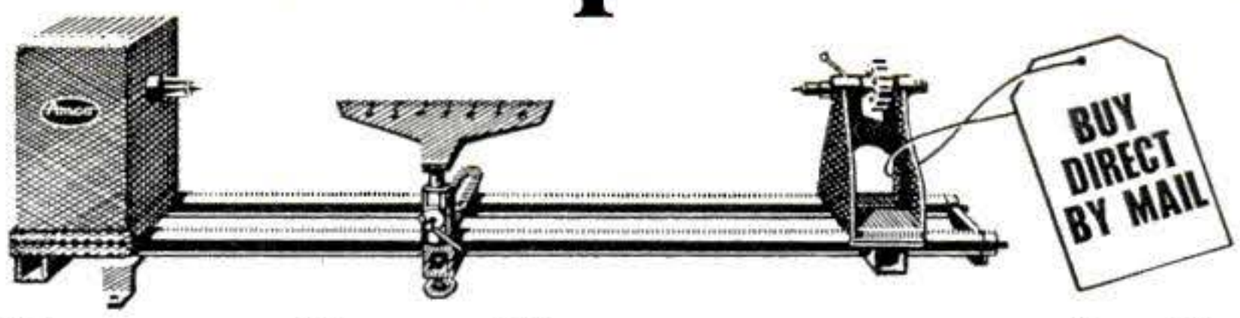

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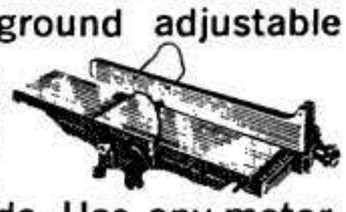

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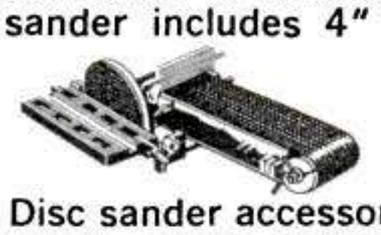

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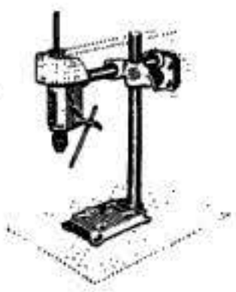

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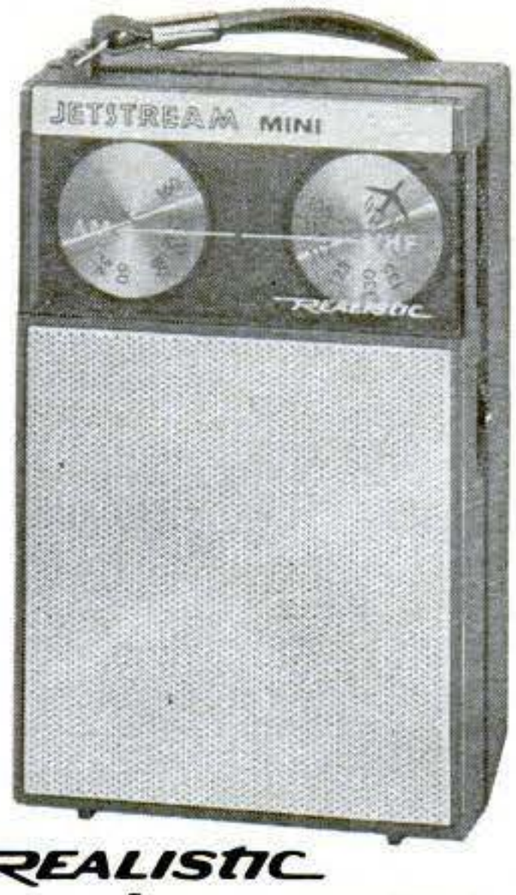

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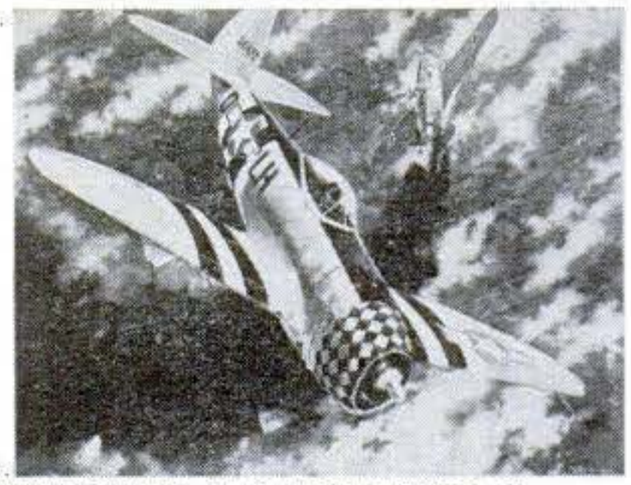

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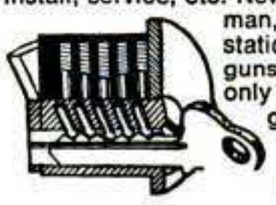

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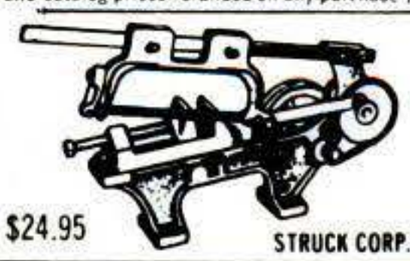

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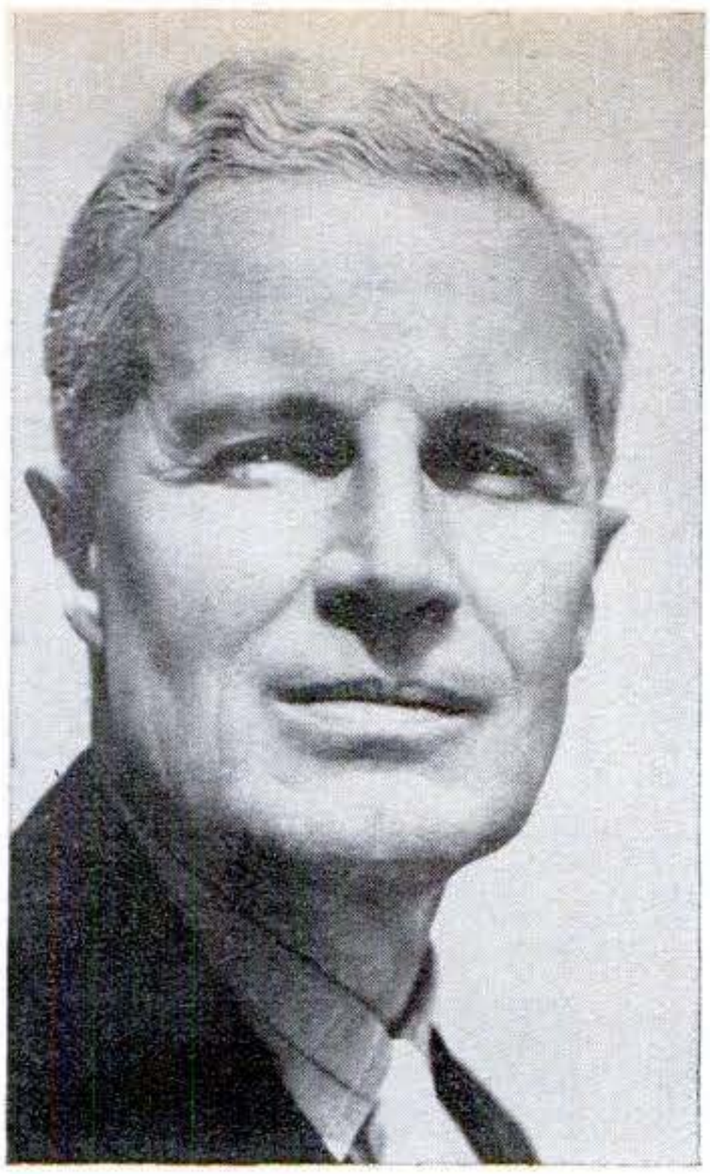

I'd like to give this to my fellow men...

while I am still able to help!

I was young once, as you may be — today I am older. Not too old to enjoy the fruits of my work, but older in the sense of being wiser. And once I was poor, desperately poor. Today almost any man can stretch his income to make ends meet. Today, there are few who hunger for bread and shelter. But in my youth I knew the pinch of poverty; the emptiness of hunger; the cold stare of the creditor who would not take excuses for money. Today, all that is past. And behind my city house, my summer home, my Cadillacs, my winter-long vacations and my sense of independence—behind all the wealth of cash and deep inner satisfaction that I enjoy—there is one simple secret. It is this secret that I would like to impart to you. If you are satisfied with a humdrum life of service to another master, turn this page now—read no more. If you are interested in a fuller life, free from bosses, free from worries, free from fears, read further. This message may be meant for you.

By Victor B. Mason

I am printing my message in a magazine. It may come to the attention of thousands of eyes. But of all those thousands, only a few will have the vision to understand. Many may read; but of a thousand only you may have the intuition, the sensitivity, to understand that what I am writing may be intended for you—may be the tide that shapes your destiny, which, taken at the crest, carries you to levels of independence beyond the dreams of avarice.

Don't misunderstand me. There is no mysticism in this. I am not speaking of occult things, of innumerable laws of nature that will sweep you to success without effort on your part. That sort of talk is *rubbish!* And anyone who tries to tell you that you can *think* your way to riches without effort is a false friend. I am too much of a realist for that. And I hope you are.

I hope you are the kind of man—if you have read this far—who knows that anything worthwhile has to be *earned!* I hope you have learned that there is no reward without effort. If you have learned this, then you may be ready to take the next step in the development of your karma—you may be ready to learn and use the secret I have to impart.

I Have All The Money I Need

In my own life I have gone beyond the need of money. I have it. I have gone beyond the need of gain. I have two businesses that pay me an income well above any amount I have need for. And, in addition, I have the satisfaction—the deep satisfaction—of knowing that I have put more than three hundred other men in businesses of their own. Since I have no need for money, the greatest satisfaction I get from life is sharing my secret of personal independence with others—seeing them achieve the same heights of happiness that have come into my own life.

Please don't misunderstand this statement. I am not a philanthropist. I believe that charity is something that no proud man will accept. I have never seen a man who was worth his salt who would accept something for nothing. I have never met a highly successful man whom the world respected who did not sacrifice something to gain his position. And, unless you are willing to make at least half the effort, I'm not interested in giving you a "leg up" to the achievement of your goal. Frankly, I'm going to charge you something for the secret I give you. Not a lot—but enough to make me believe that you are a little above the fellows who merely "wish" for success and are not willing to sacrifice something to get it.

A Fascinating and Peculiar Business

I have a business that is peculiar—one of my businesses. The unusual thing about it is that it is needed in every little community throughout this country. But it is a business that will never be invaded by the "big fellows." It has to be handled on a local basis. No giant octopus can ever gobble up the whole thing. No big combine is ever going to destroy it. It is essentially a "one man" business that can be operated without outside help. It is a business that is good summer and winter. It is a business that is growing each year. And, it is a business that can be started on an investment so small that it is within the reach of anyone who has a television set. But it has nothing to do with television.

This business has another peculiarity. It can be started at home in spare time. No risk to present job. No risk to present income. And no need to let anyone else know you are "on your own." It can be run as a spare time business for extra money. Or, as it grows to the point where it is paying more than your present salary, it can be expanded into a full time business—overnight. It can give you a sense of personal independence that will free you forever from the fear of lay-off, loss of job, depressions, or economic reverses.

Are You Mechanically Inclined?

While the operation of this business is partly automatic, it won't run itself. If you are to use it as a stepping stone to independence, you must be able to work with your hands, use such tools as hammer and screw driver, and enjoy getting into a pair of blue jeans and rolling up your sleeves. But two hours a day of manual work will keep your "factory" running 24 hours turning out a product that has a steady and ready sale in every community. A half dollar spent for raw materials can bring you six dollars in cash—six times a day.

In this message I'm not going to try to tell you the entire story. There is not enough space on this page. And, I am not going to ask you to spend a penny now to learn the secret. I'll send you all the information, free. If you are interested in becoming independent, in becoming your own boss, in knowing the sweet fruits of success as I know them, send me your name. That's all. Just your name. I won't ask you for a penny. I'll send you all the information about one of the most fascinating businesses you can imagine. With these facts, you will make your own investigation. You will check up on conditions in your neighborhood. You will weigh and analyze the whole proposition. Then, and then only, if you decide to take the next step, I'll allow you to invest $15.00. And even then, if you decide that your fifteen dollars has been badly invested I'll return it to you. Don't hesitate to send your name. I have no salesmen. I will merely write you a long letter and send you complete facts about the business I have found to be so successful. After that, you make the decisions.

Does Happiness Hang on Your Decision?

Don't put this off. It may be a coincidence that you are reading these words right now. Or, it may be a matter that is more deeply connected with your destiny than either of us can say. There is only one thing certain: If you have read this far you are interested in the kind of independence I enjoy. And if that is true, then you must take the next step. No coupon on this advertisement. If you don't think enough of your future happiness and prosperity to write your name on a postcard and mail it to me, forget the whole thing. But if you think there is a destiny that shapes men's lives, send your name now. What I send you may convince you of the truth of this proverb. And what I send you will not cost a penny, now or at any other time.

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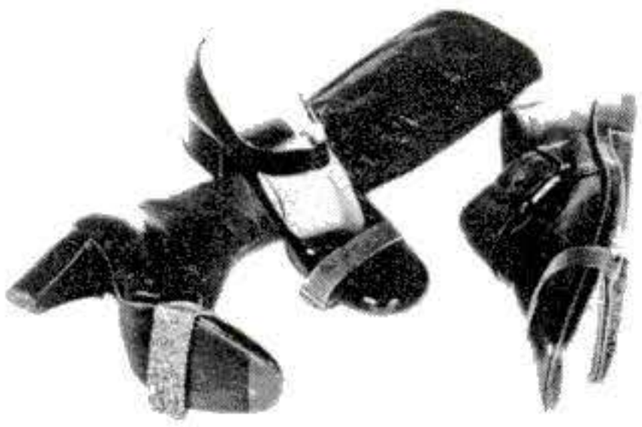

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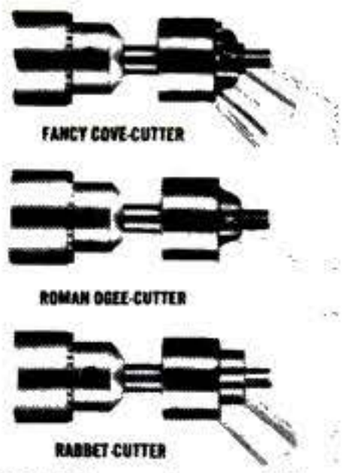

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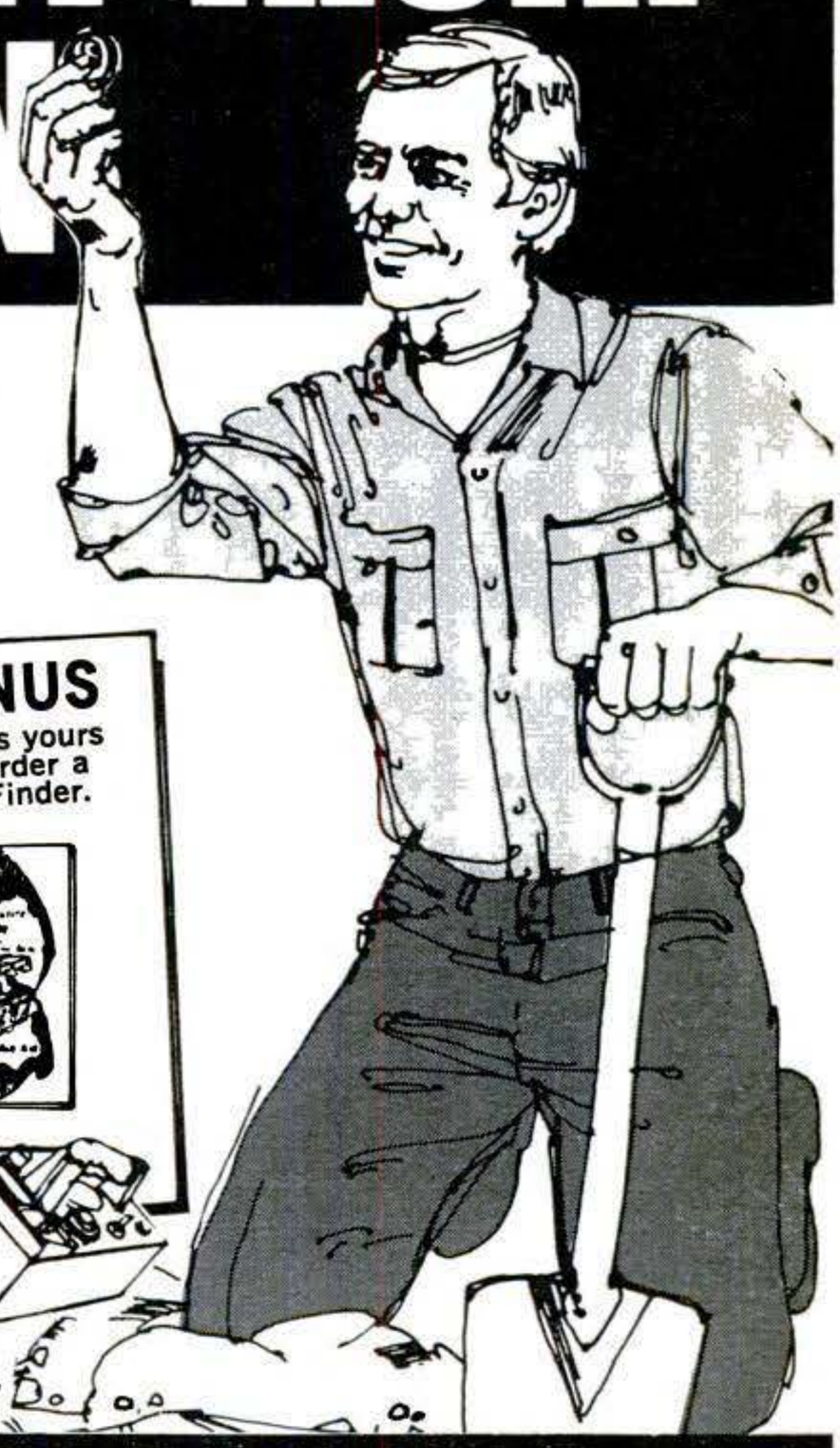

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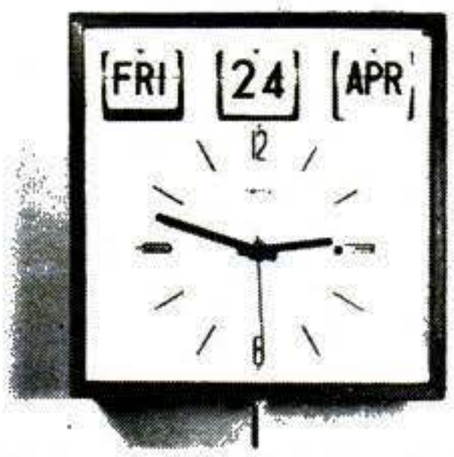

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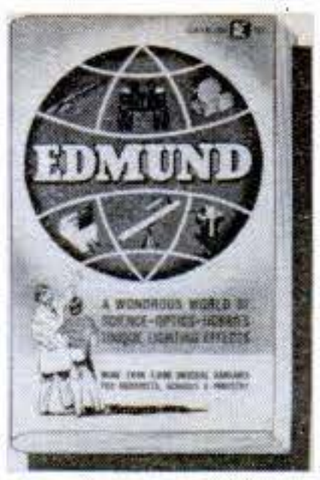

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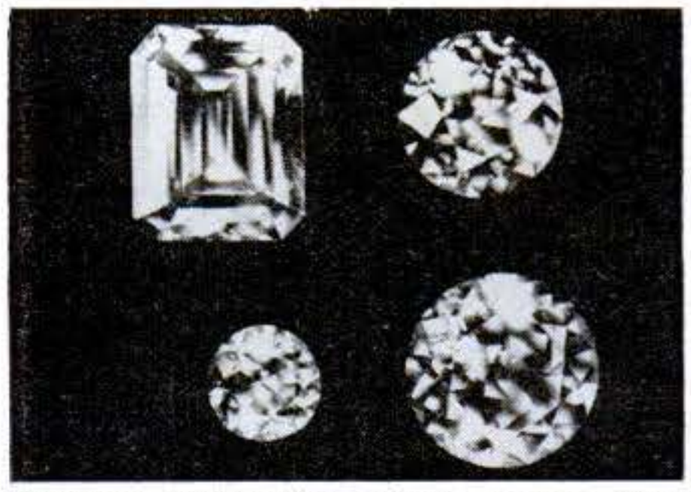

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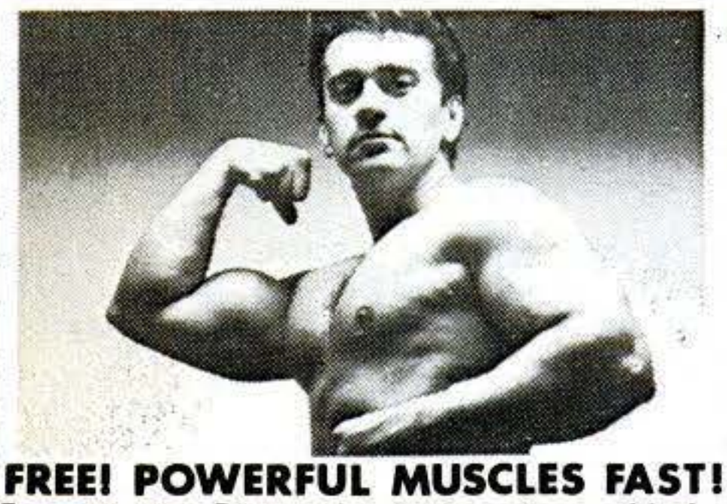

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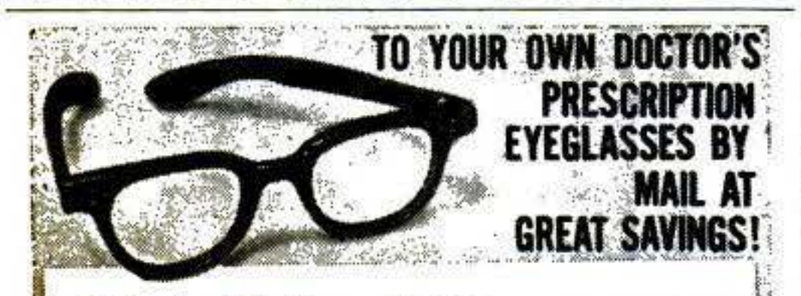

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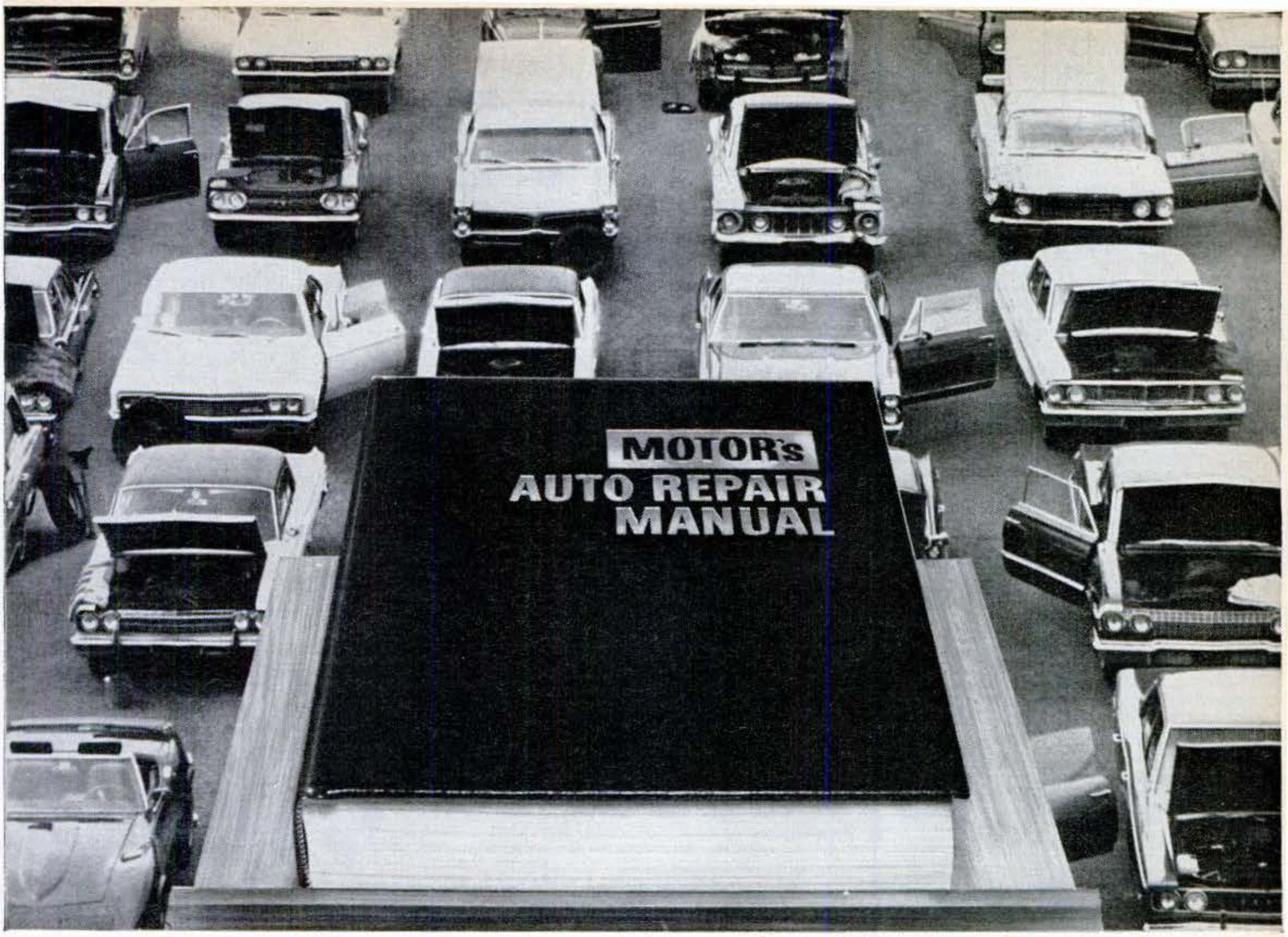

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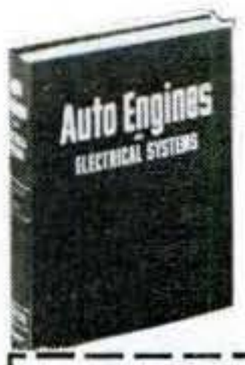

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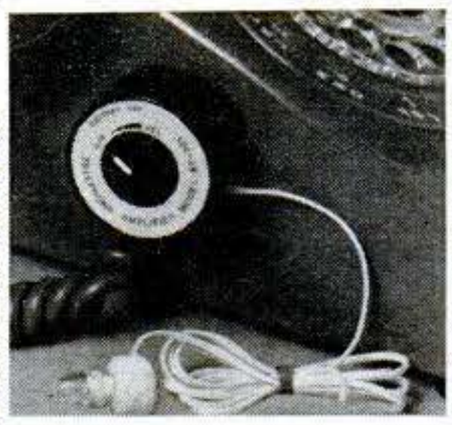
PHONE MONITOR & TELEPHONE AMPLIFIER

Can Be Used With Phone on Or Off Hook



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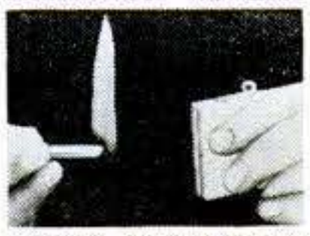

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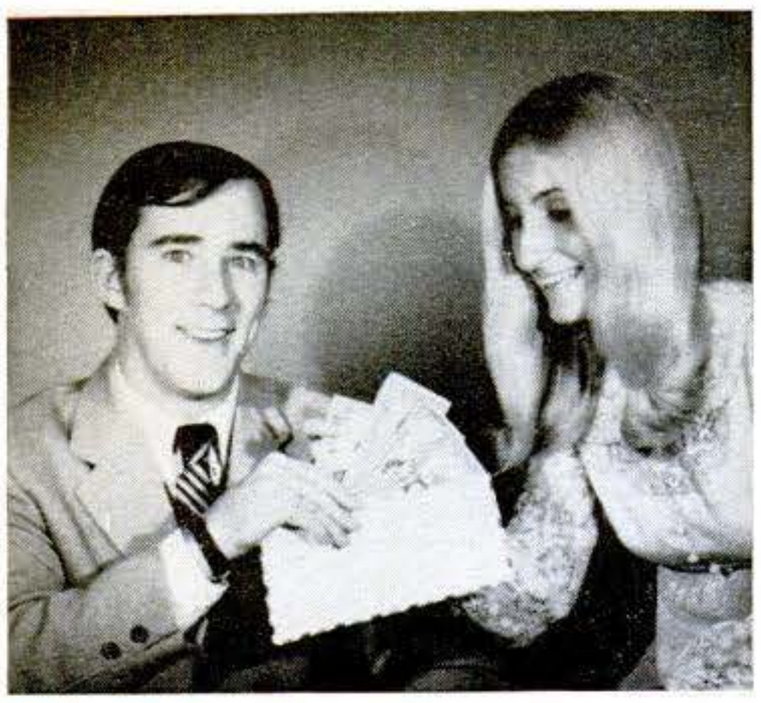
START YOUR OWN BUSINESS RIGHT FROM YOUR HOME — AND MAKE A FORTUNE IN MAIL ORDER!



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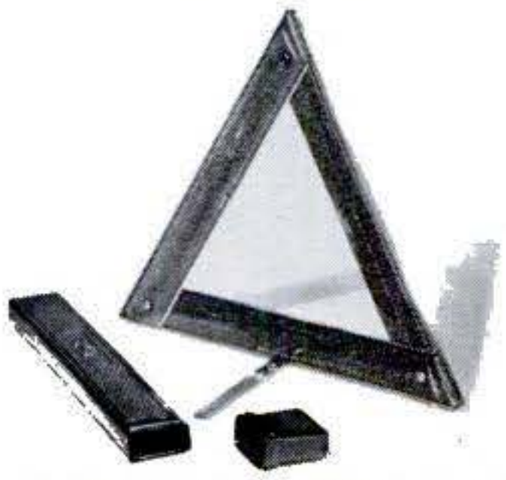

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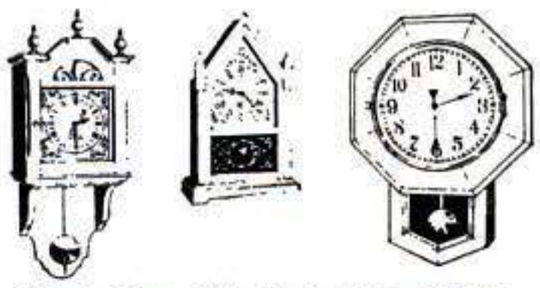

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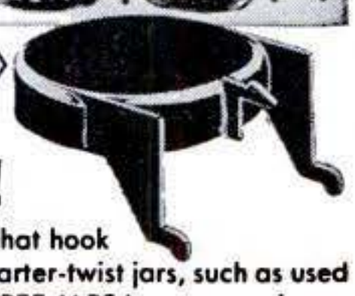

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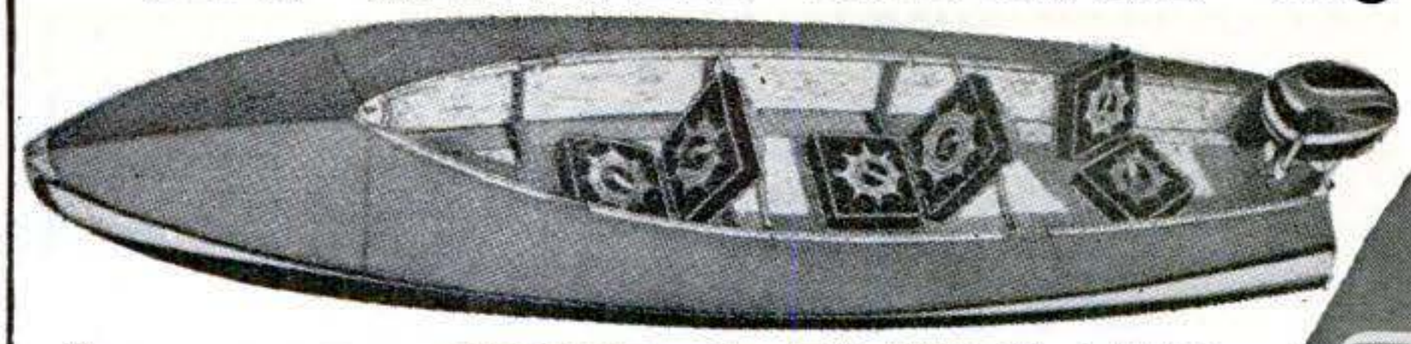

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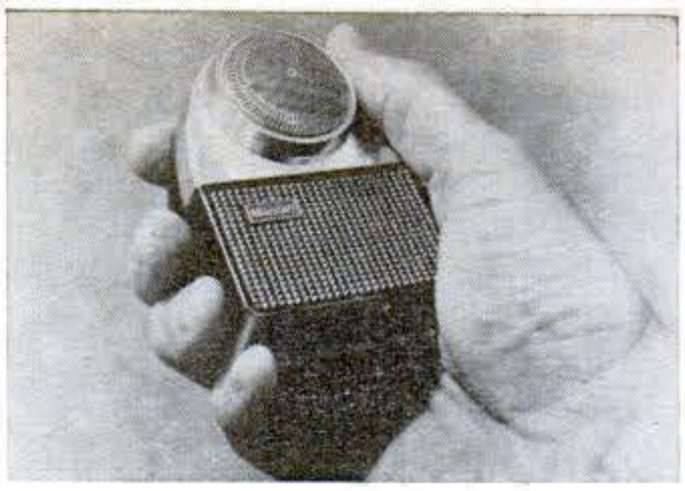

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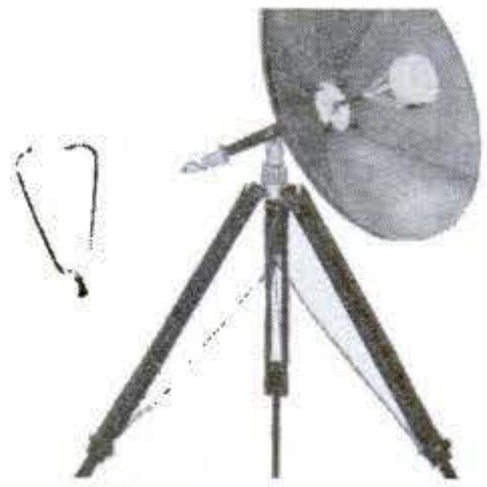

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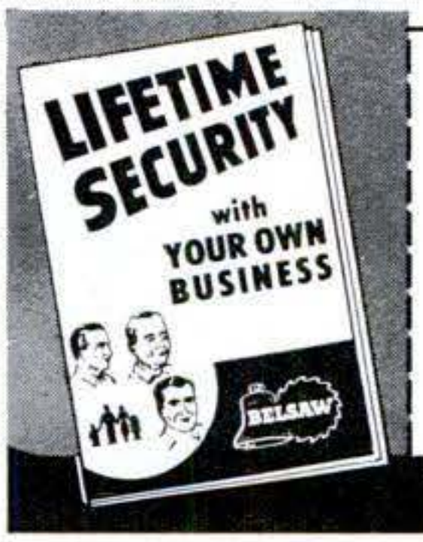

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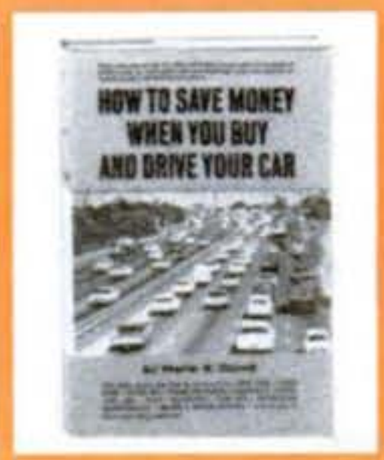

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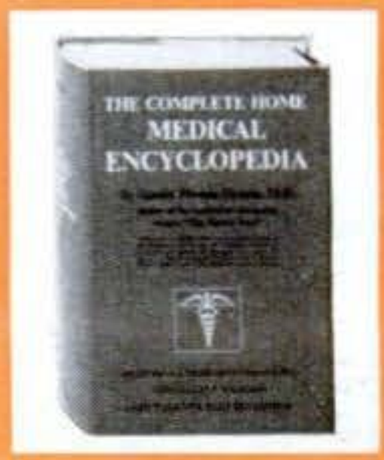

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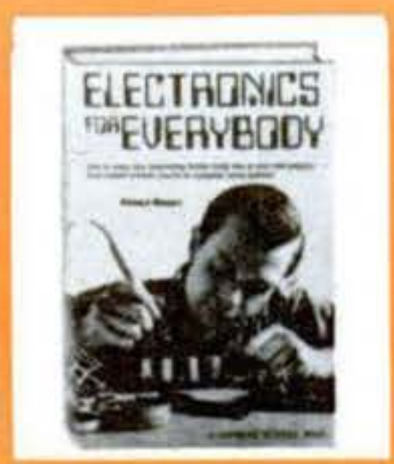

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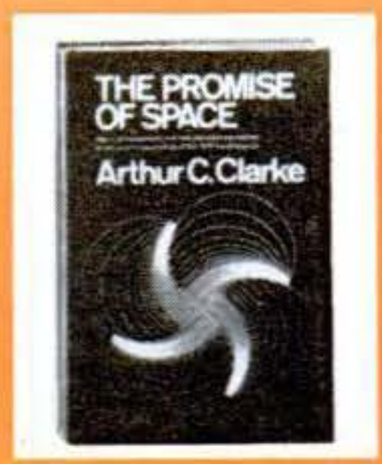

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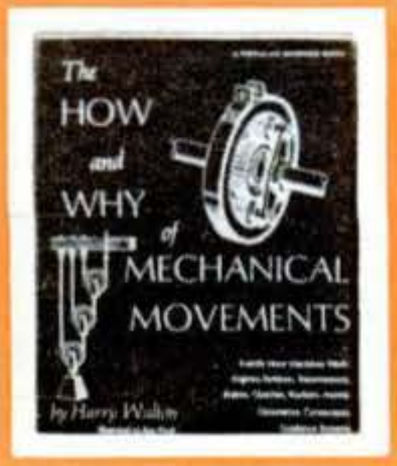

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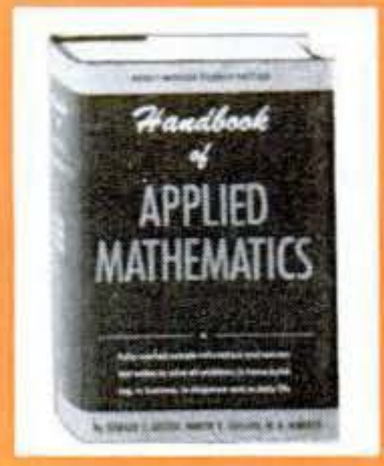

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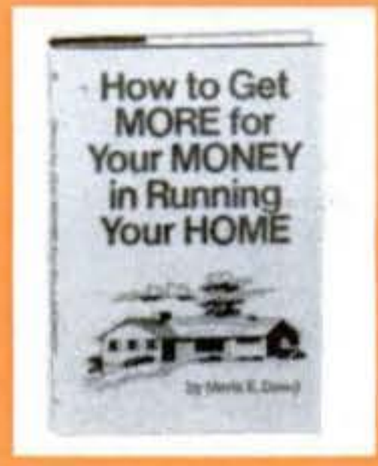

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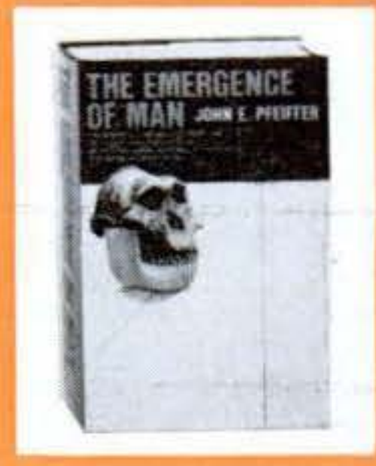

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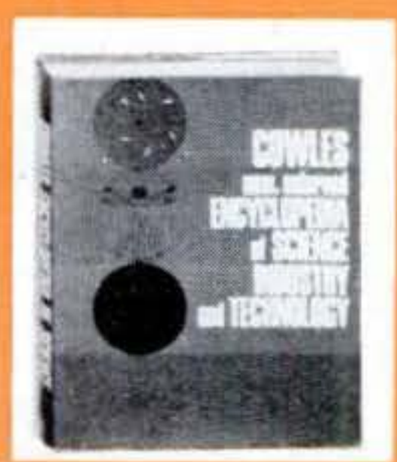

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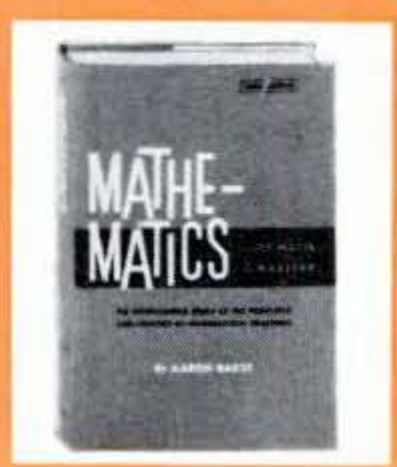

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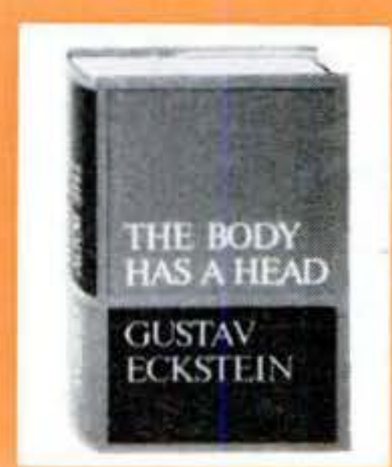

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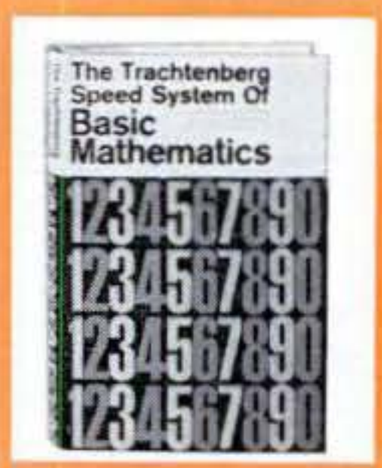

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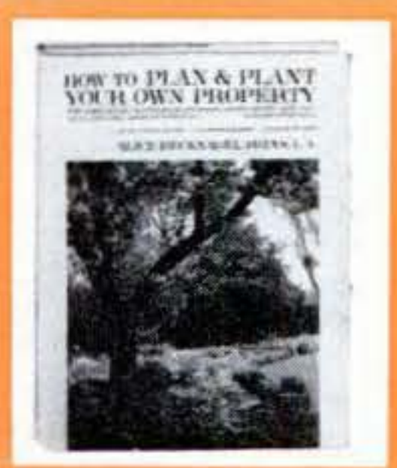

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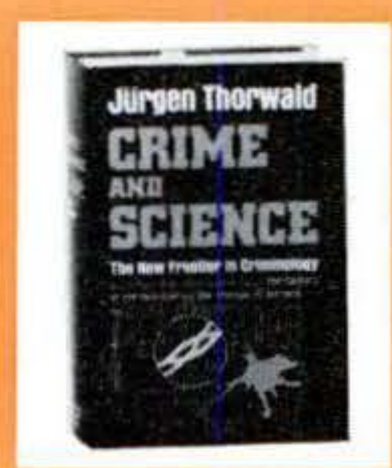

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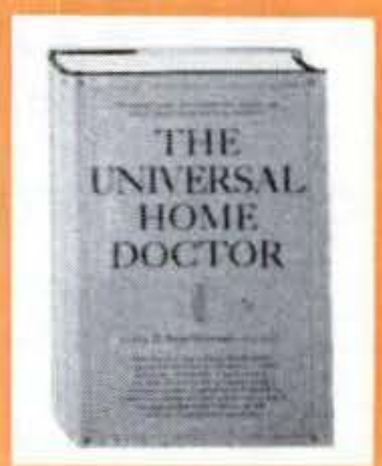

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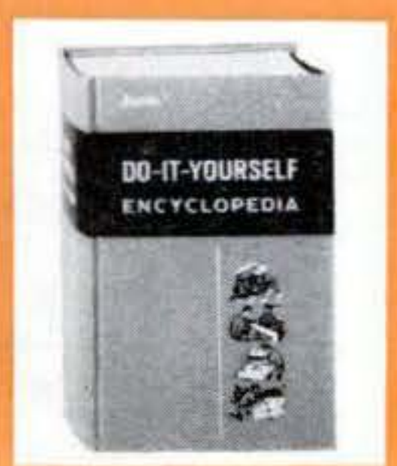

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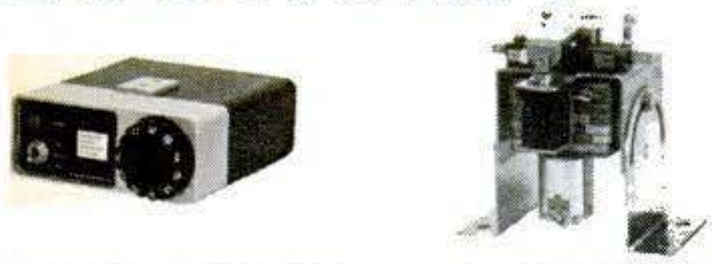

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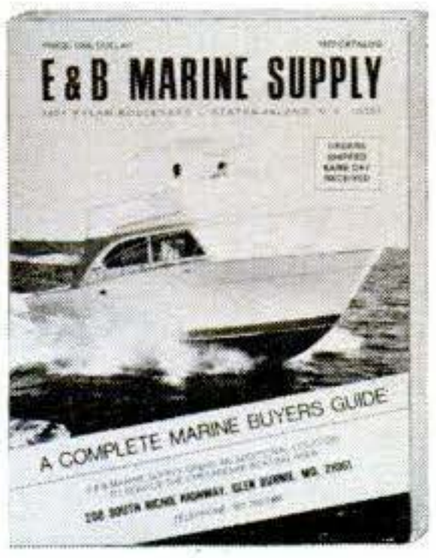

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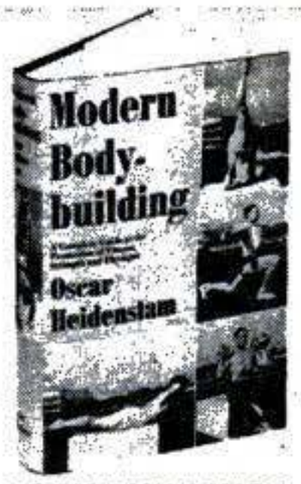

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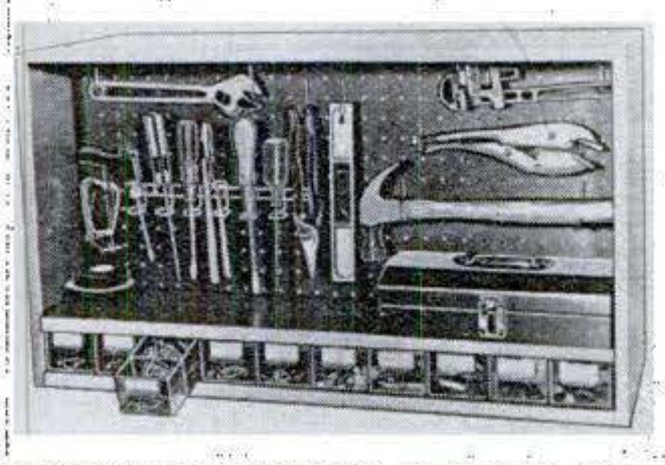

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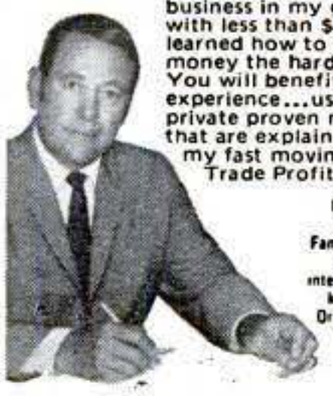

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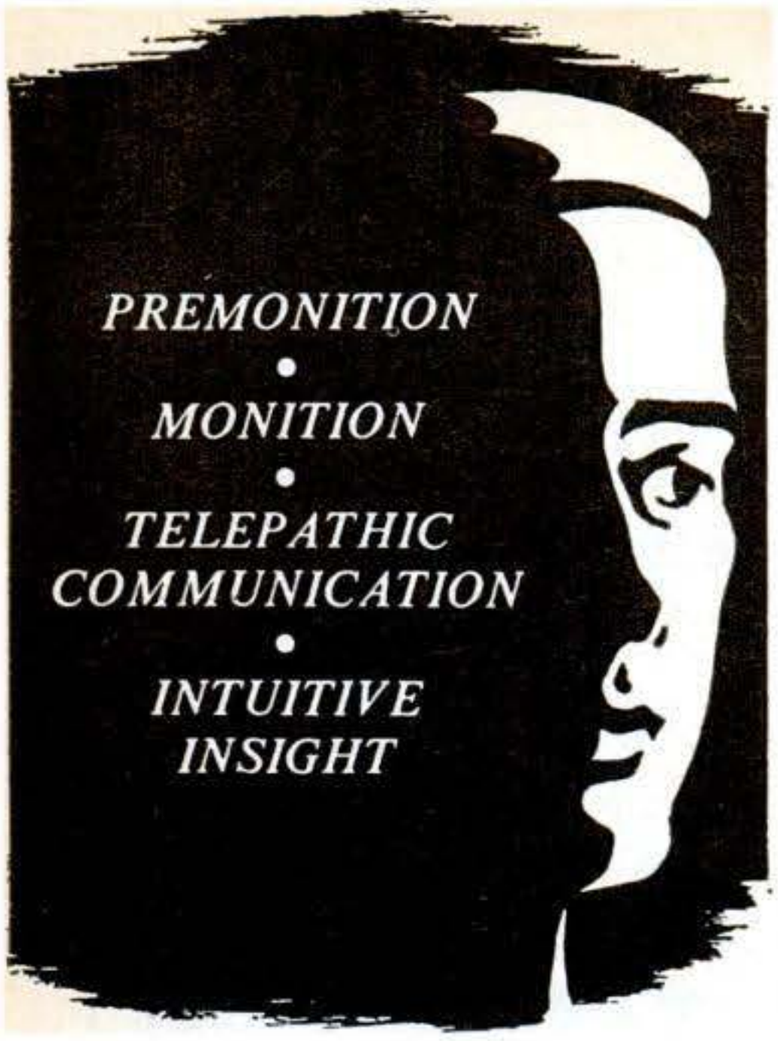

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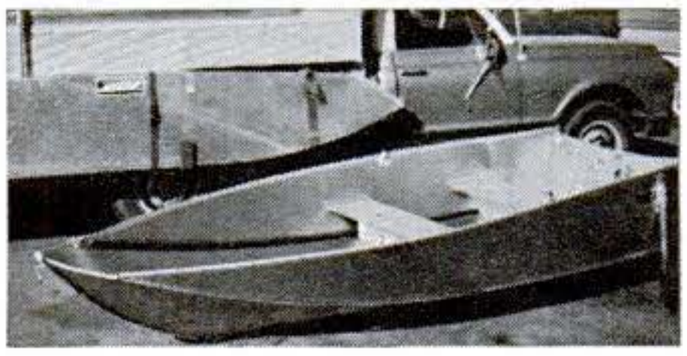

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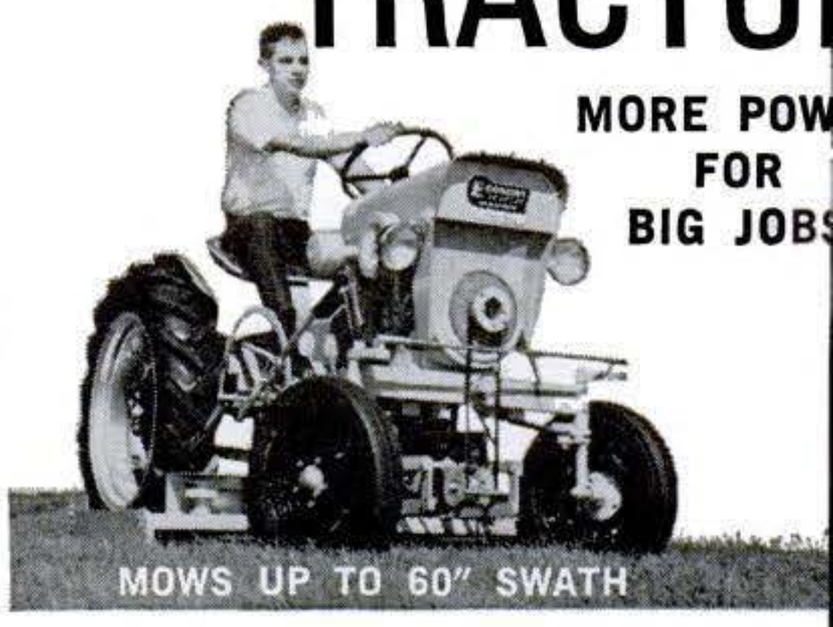

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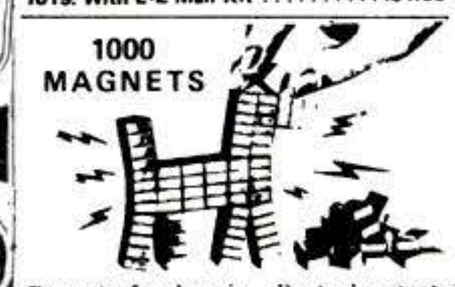

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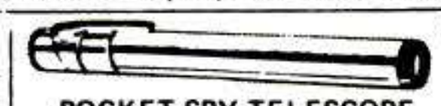

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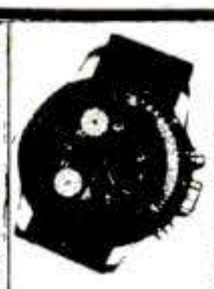

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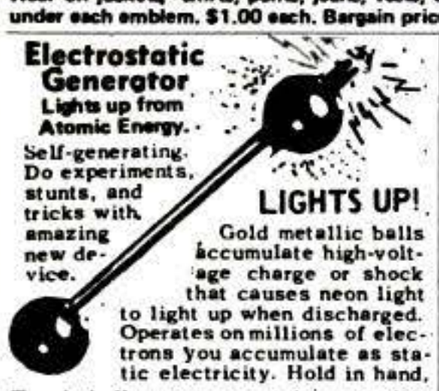

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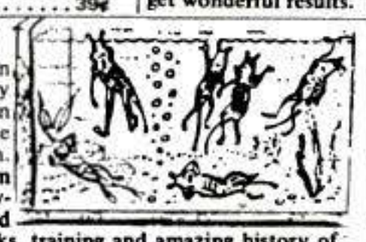

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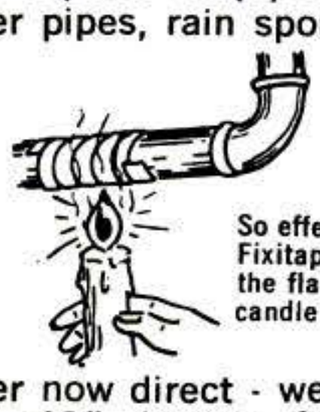

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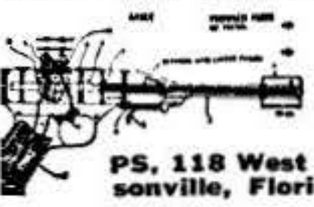

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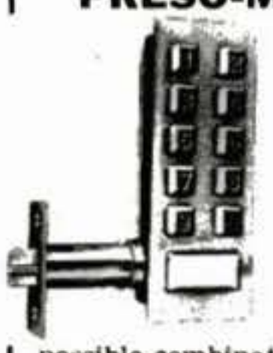

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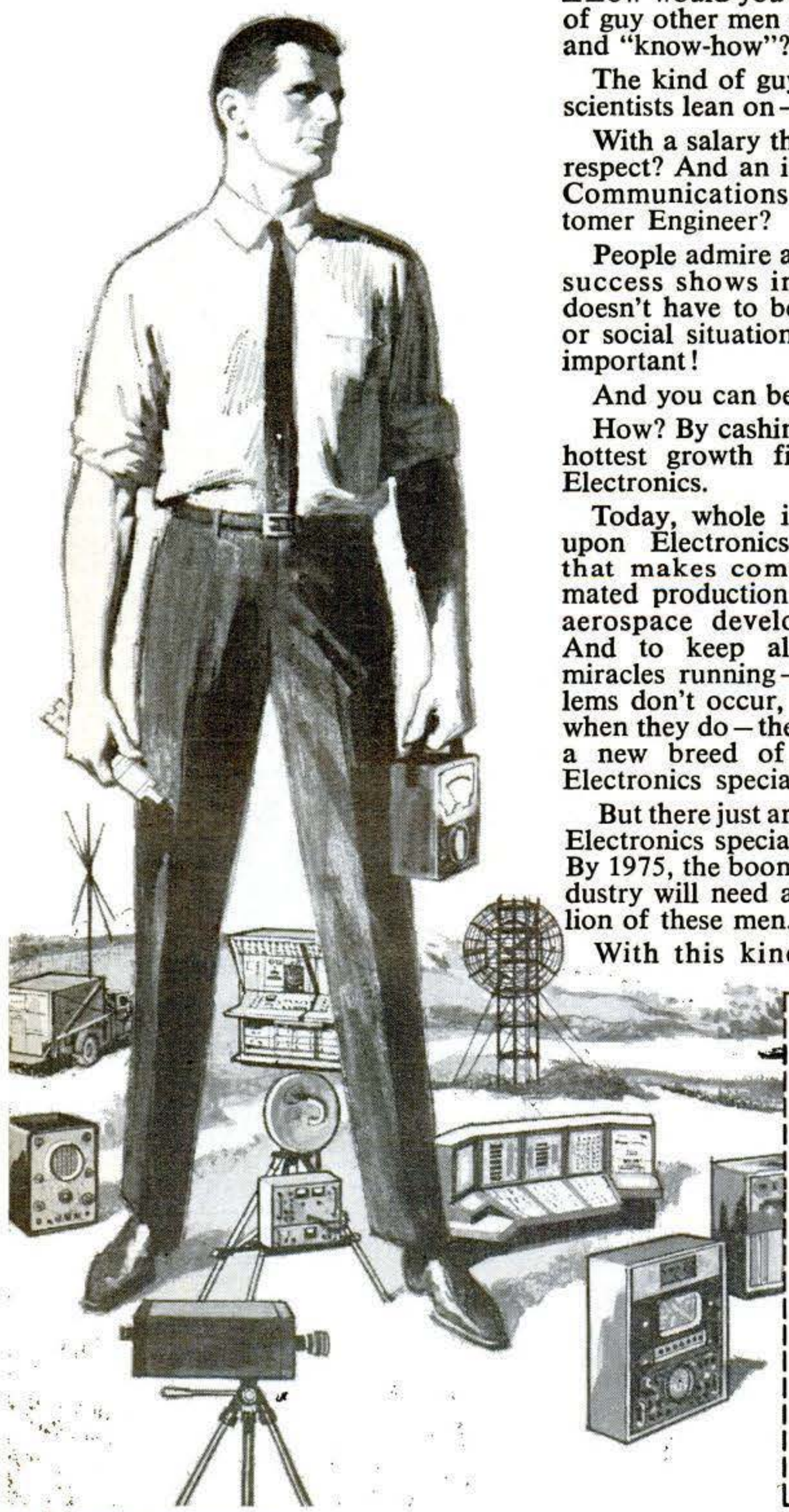

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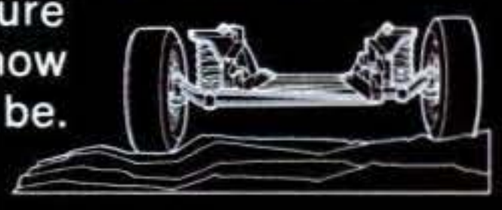

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